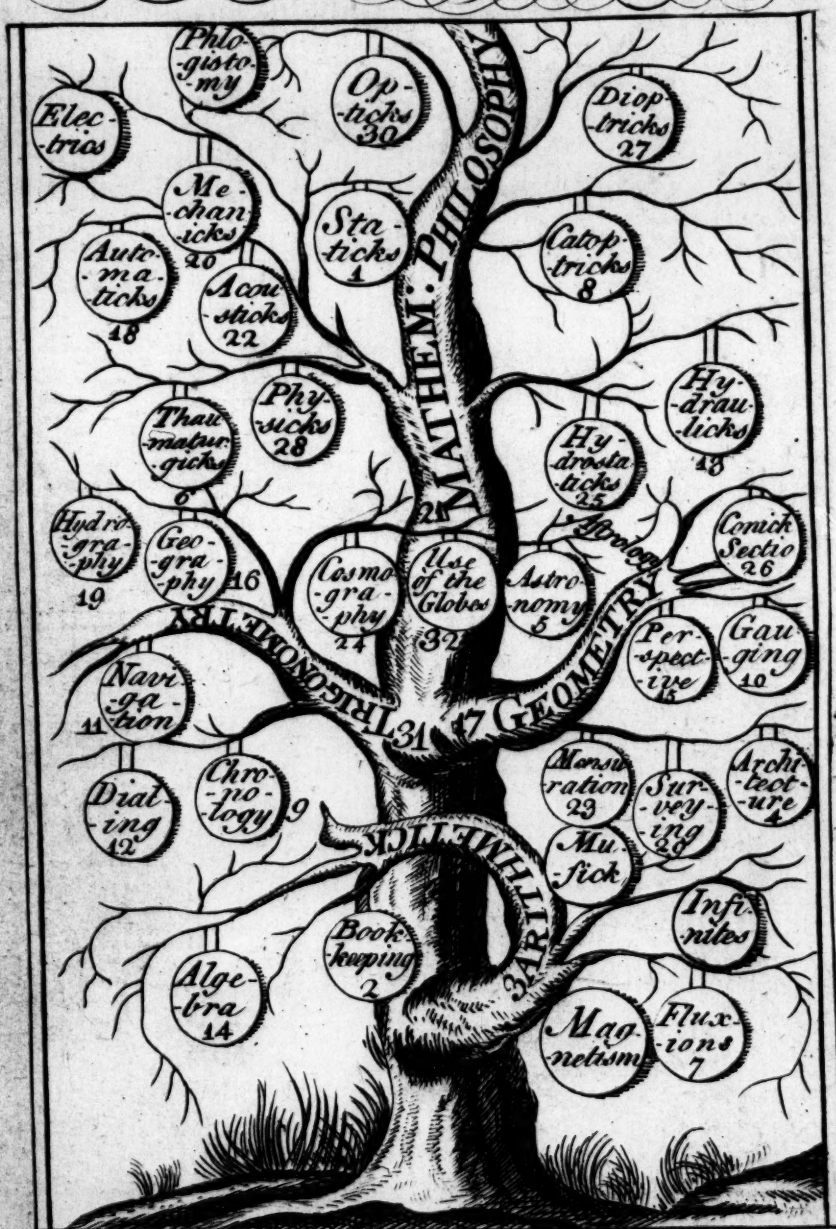


MATHESEOS Emblema



Printed and sold by Isaac Jackson and Son;
Improved, and much enlarged.

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A *Joseph Hardy*

MATHEMATICAL MISCELLANY

IN FOUR PARTS.

- I. An ESSAY towards the probable Solution of *GORDON*'s Forty five Surprising Geographical *Paradoxes*, and others added in this Edition.
- II. Fifty five New and Amazing *Paradoxes* and *Enigmas*, some in Verse, some in Prose, with their Solutions; to which are subjoined several others, left unanswered for the Amusement of the Ingenious of either Sex.
- III. ANSWERS to the Hundred Questions, formerly left unanswered in *HILL*'s Arithmetick and *ALEXANDER*'s Algebra, and a Select Number of Curious Questions left unanswered.
- IV. Miscellaneous Rules about forming *Enigmas*, Questions, &c. A Discourse concerning the Principles of Astronomy, Doctrine of Eclipses, Properties of Pendulums, Equation of Time and Chronology; concluding with a Perpetual Almanack, and Rules for finding all the Moveable Feasts in both new and old Stile.

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The Third EDITION, Corrected.

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MISCELLANY

PART I

Concerning PARADOXES.

A PARADOX is a *seeming* Falsity, but a *real* Truth; 'tis that which to *unthinking* Persons, seems absurd or impossible; but to a *thoughtful* Man, is plain and evident: The main Drift whereof is to *whet* the Appetite of an *inquisitive* Learner, and to set him upon *Thinking*.

GORDON's Paradoxes solv'd.

1. **T**HERE are two remarkable Places on the *Globe* of the Earth, in which there is only one Day and one Night throughout the whole Year.

Answer, The two remarkable Places are the two *Poles*; for to the *North Pole*, the *Sun* rises about the 21st of *March*, and sets not till about the 23^d of *September*: And the ensuing *Twilight* continues till the *Sun* be eighteen Degrees below the *Horizon*, i. e. about the 13th of *November*, then dark Night continues till about the 29 of *January* at which Time the Day breaks, and the Morning *Twilight* continues 'till *Sun* rise on the 21st of *March*. Hence betwixt *Sun* rise and *Sun* set are six Months, but betwixt Day-break and *Twilight's* End are about two Hundred and eighty eight Days, but Totally dark only seventy seven Days.

4 Gordon's PARADOXES sol'd.

NOTE, When it rises to the *North Pole*, it sets to the *South*, & *e contra*; and because it rises but once, and sets but once in the Year, to either, there is but one Day and one Night in the whole Year.

2. There are also some Places on the Earth in which 'tis neither Day nor Night, at a certain Time of the Year, for the Space of twenty four Hours.

Answer, If by *neither Day nor Night*, be meant *Twilight*, it may be any Climate of the *Frigid Zones*; but if it be understood that the *Sun* neither rises nor sets for 24 Hours, the Places must be ninety Degrees distant from the *Sun*: Thus, if the *Sun* be in the *Equator*, then the *Poles* are the Places; for at those Times the *Sun* circuits about their *Horizon* for twenty four Hours, half above and half under it; hence for so long, 'tis neither Day nor Night then and there.

3. There is a certain Place of the Earth, at which, if two Men should chance to meet, one would stand upright upon the Soles of the other's Feet, and neither of them should feel the other's Weight, and yet they both should retain their natural Posture.

Answer, He says of the *Earth*, not on the *Earth*, which therefore means the Center thereof; for imagine an Hole bor'd thro', from our Feet, to and thro' the Center of the *Earth*, to the opposite Point, or the *Antipodes*, and one Man descended towards the Center at one End of the Hole, and another Man descended at the other End of the Hole, till they both met at the Center, so would they stand on each other's Feet, with their Heads towards the *Zenith*, in their natural Posture without feeling each other's Weight. According to these Maxims, *No heavy Bo'y gravitates in the Center*, and *All heavy Bodies tend to the Center*; whereas a *Gravitation* at the very Center, must imply necessarily a *Divergency* from the Center, or an Ascent, which is absurd.

4. There is a certain Place of the Earth, where a Fire being made, neither Flame nor Smoke would ascend, but move circularly about the Fire: Moreover, if

Gordon's PARADOXES solv'd.

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if in that Place one should fix a smooth or plain Table, without any Ledges whatsoever, and pour thereon a large Quantity of Water, not one Drop thereof would run over the said Table, but would raise itself up in an Heap.

Answer. This Place must also be the Center of the Earth, for the Reasons mention'd in the last.

5. There is a certain Place on the *Globe*, of a considerable *Southern* Latitude, that hath both the greatest and least Degree of Longitude.

Answer. This may either mean the *South Pole*, which hath not only the least but greatest, and all intermediate Degrees of Longitude, all which meet in the *Poles*. Or all Places that lie under the first *Meridian*, have both the least and greatest Degree of Longitude, as at Noon is the greatest and least Number of Hours; because then and there we begin and end our Reckoning.

Thus *Trinidad*, is in Latitude *South*, 20 Degrees, and under the first *Meridian*, with them who reckon from *St. Michael's*, or *Tristram da Cunha*, is in thirty six Degrees fifty four Minutes *South* Latitude, and the same Longitude, with *Teneriff*; all which, according to the old Way of reckoning Longitude, are not only in the Beginning of the first Degree, but also in the End of the three Hundred and sixtieth Degree of Longitude.

6. There are three remarkable Places on the *Globe* that differ both in Longitude and Latitude, and yet all lie under one and the same *Meridian*.

Answer. By the *Globe*, may be meant the *Artificial Globe*; and by the *Meridian* may be meant the *Brazen Meridian*, belonging to it, which may be five Degrees thick; then suppose three Places, *A*, *B*, *C*; *A* to be *Dublin*, in Latitude fifty three Degrees and one third, and Longitude twenty Degrees; *B* to be *Lisbon*, in Latitude thirty eight Degrees and an half, Longitude eighteen Degrees; *C* to be the Isle of *Paxaros*, in Latitude eight Degrees, and Longitude two Hundred Degrees, all which tho' they differ both in

6 Gordon's PARADOXES solv'd.

Longitude and Latitude, yet may they all lie under one and the same *Brazen Meridian*.

Or without Equivocation, suppose one Place under the *Pole*, a second on this Side, and a third on the other under the same *Meridian Circle*, so may they all differ both in Longitude and Latitude; for the *Pole* contains all Degrees of Longitude.

7. There are three remarkable Places on the *Continent of Europe*, that lie under three different *Meridians*, and yet all agree both in Longitude and Latitude.

Answer, Divers *Geographers* begin their first *Meridian* at divers Places; thus *Ptolomy* at *Cape Verde* (formerly one of the *Fortunate Islands*) *Mercator* at *St. Michael's* in the *Azores*; *Bleau* at *Teneriff*, one of the *Canary Isles*, &c. Now if you take (under the same Latitude) three Places (suppose ten Degrees from each of these first *Meridians*) they agree all in Latitude, also in Longitude, from these three respective Places, and yet lye under three different *Meridians*, in respect of the *Globe*, or which is much to the same purpose, chuse any three Places under different *Meridians*, and one Parallel of Latitude, as *Pico*, *St. Nicholas*, and *Lisbon*, and begin the Longitude at every one of them; so will they all be first *Meridians*, and agree in having no Longitude, and being in the same Parallel will agree also in Latitude.

8. There is a certain Island in the *Ægean Sea*, upon which if two Children were brought forth at the same Instant of Time, and living together for several Years, should both expire on the same Day, yea at the same Hour and Minute of the Day, yet the Life of one would surpass the Life of the other by divers Months.

Answer, Different Parts of the said Island may be supposed to compute differently, some by the *Solar Year*, some by the *Lunar*; or some use different Courses of the *Moon*; in one Place her *Periodical*, and in other Places her *Synodical*, which is a larger Revolution than the former; so within the Compass of some Years the Difference will amount to several Months: Or suppose the Island to be *Negropont*, in the
Ægean

Aegean Sea, where both *Christians* and *Turks* dwell; now the *Turks* follow the *Lunar Year*, which is 11 Days less than the *Solar*, which the *Christians* account by. Now if the Children should live thirty *Solar Years* together, and then die, the *Turks* would account them about 10 Months older than the *Christians*. Or if one of the Children sails directly *East*, and the other directly *West*, when they encompass the *Globe* of the *Earth* once (which is now easily done in a Year) there will be two Days Difference in their Age, and in forty Years thus Sailing, the one will be eighty Days older than the other. Or suppose the one lives without the *Arctic Circle*, where no Day exceeds twenty-four Hours, and the other goes and lives in the Latitude of seventy-three Degrees twenty Minutes, where the Day is 3 Months long, and then returns, and both die at one Instant, the one will be three Months older than the other; but the two first Solutions seem preferable, because of these Words in the Paradox, *living together for several Years*; yet because the two last carry Instruction along with them, I would not omit the mentioning of them.

9. There are two observable Places belonging to *ASIA* that lie under the same *Meridian*, and of a small Distance from one another; and yet the respective Inhabitants of them, in reckoning their Time, do differ an entire natural Day every Week.

Answer, This also may be solved two Ways, first if they keep their Sabbaths on different Days of the Week, as the *Christians* on Sunday, the *Greeks* on Monday, the *Persians* on Tuesday, the *Assyrians* on Wednesday, the *Egyptians* on Thursday, the *Turks* on Friday, the *Jews* on Saturday. Or better thus, the two Places are, one *Macao*, and the other the *Philippine Isles*, near each other and under the same *Meridian*, yet they differ one Day in their Account; for, in the *Philippine Isles*, with the *Spaniards* when it is their last Saturday in Lent, the *Portuguese* in *Macao*, eat Flesh, it being their first Sunday in *Easter*: The Cause of this Difference is, the *Spaniards* sailed thither *Westerly*, and lost half a Day, and the *Portuguese* sailed thither *Easterly* and gained half a Day.

8 Gordon's PARADOXES solv'd.

10. There is a particular Place of the Earth where the Winds (tho' frequently veering round the *Compass*) do always blow from the *North Point*.

Answer, Under the *South Pole* directly; for all Winds blowing there must needs blow *North*, as all Winds blowing at the *North Pole* must needs blow *South*, because there the *Meridians*, which are *North* and *South*, are the *Azimuths* all concentring in the *Pole*, which is their *Zenith*.

11. There is a certain Hill, in the *South* of *BOHEMIA*, on whose Top, if an Equinoctial Sun-Dyal be duly erected, a Man that is Stone-blind may know the Hour of the Day by the same, if the *Sun* shines.

Answer, Perhaps it never doth shine on that Hill because there is a Mountain that is said to encircle all *BOHEMIA*, or never till Noon; so then, if you tell the blind Man the *Sun* shines, he'll tell you 'tis Twelve o'Clock: Howbeit I know not a better Way to make a blind-Man's Sun-Dyal than this.

Fill a Glass Globe with Water, which fix in a Sphere, with Twelve polished Iron Meridians each having so many Nicks as the Number of Hours belonging thereto; which let be fixed, precisely at the Distance of the *Focus*, from the *Globe*, so will the *Globe* full of Water unite the Solar Rays that they will burn at a Distance; thus this Equinoctial Dyal being fix'd in the Sun-shine, on a Hill or Valley, one that is Stone-blind may feel which *Meridian* is hottest, and grope out, by the Nicks, the Number of the present Hour.

12. There is a considerable Number of Places, lying within the *Torrid-Zone*, in any of which, if a certain kind of *Sun-Dyal* be duly erected, the Shadow will go back several Degrees upon the same at a certain Time of the Year, and that twice every Day, for the Space of divers Weeks; yet no ways derogating from that miraculous returning of the Shadow upon the *Dyal* of *Abaz*, in the Days of King *Hezekiab*.

Answer,

Answer, Any where in the *Torrid Zone*, where the Latitude is less than the Declination of the *Sun*, and both towards the same *Pole*: The *Sun* comes twice to the same Point of the *Compass* both Forenoon and Afternoon; and on an Equinoctial Dyal, placed Horizontally, the Shadow of the Gnomon shall go back, *plus minus*, twice every Day. But because the Paradox mentions a certain kind of Dyal, I suppose it may be thus answered, by a plain Equinoctial Dyal, describ'd on both Sides of a Horizontal Plain, and with two Gnomons, and near the *Tropic*, when the Latitude and Declination are equal; before the *Sun* comes to the Mathematical *Horizon* in the Morning, he will shine on the lower Side of the Plane, and the Shadow of the Gnomon will run *Westward*, *ad infinitum*, and presently after six o'Clock, as he shines on the upper Plane, the shadow runs *Eastward* till Noon, and thence to six in the Evening, at which Time the shadow, on the lower Plane, will begin, and run *Westward* till Sun set; there may, by Concave, Convex and Reflex Dyals, be other Ways of solving this.

Note, In the Latitude Eighteen Degrees *North*, the Retrogradation of the Shade will continue, more, or less, from the 12th of *May*, to the 31th of *July*, i. e. Eighty Days, which the *Sun* spends in moving from Eighteen Degrees *North* Declination, till it come back to the same Degree again.

13. There are divers Places on the *Continent* of *AFRICA*, and the Islands of *Sumatra* and *Borneo*, where a certain kind of Sun-Dyal being duly fix'd; the Gnomon thereof will cast no Shadow at all, during several Seasons of the Year: and yet the exact Time of the Day may be known thereby.

Answer, An Horizontal Dyal, under the Equinoctial Line, casts no Shadow at Twelve o'Clock, Twice every Year, or because the Places mention'd in the Paradox are betwixt the *Tropics*, the *Sun* comes Twice in the Year to their *Zenith*, and then the Gnomon casts no Shadow exactly at Noon; or it may be the blind Man's Dyal aforesaid in the Eleventh Paradox: But I rather take it to be a *Globe*, rectified according to the Latitude and Day of the Month and the Index to the Hour Twelve, and to the *Sun's* Place apply a Perpendicular

10 *Gordon's PARADOXES* solv'd.

dicular or Spheric Gnomon, which is to be there fix'd, and the Globe turned till it casts no Shadow, so will the Globe's Index point out the Hour any Time when the *Sun* shines, as well in these Parts of the World as in those Islands; for Dyals may be made to shew the Hour, without Shade of either Stile or Hour-Line, as a Globical Dial, having a movable Equator, and a fixed Stile or Gnomon thereon.

14. There is a certain Island in the vast *Atlantic Ocean*, which being descry'd by a Ship at Sea, and bearing due *East* off the said Ship, at twelve Leagues Distance by Estimation; the truest Course for hitting the said Island, is to steer six Leagues due *East*, and just as many due *West*.

Answer, The Prime Meridian, from whence Longitude is accounted, both Ways, *East* and *West*, passes thro' the Middle, betwixt the Ship and Island, and to Regard is had to the *East* and *West* Longitude, and not to the Points of the Compass.

15. There is a remarkable Place in the *Globe* of the Earth, of a very pure and wholsom Air to breath in; yet of such a strange and detestable Quality, that it's absolutely impossible for two of the intirest Friends that ever breathed, to continue in the same in mutual Love and Friendship for the space of two Minutes of Time.

Answer, 'Tis impossible for two Persons to be in one and the self same individual Place together: Others say, by Reason of the Earth's Motion they cannot continue in the same Air; others say, two in the Throne cannot continue in mutual Love and Friendship; or there may be Vulcano's Caves and Lakes, which emit sulphurous, pestilential and killing Vapours, tho' situate in a pure wholsom Air; as *SICILY*, *JUDÆA* and *ICELAND*, in which are an *Ætna* or dead Sea, and in the last both; but I rather take it to be directly under the *Poles*, which, by Reason of the superlative Cold, must needs have a pure Air; but we hear of none that ever got within an hundred Leagues of them, let alone to stay two Minutes there, by Reason of the

Mountains

Gordon's PARADOXES solv'd. II

Mountains of Ice, frozen Sea, and excess of Cold for a thousand Miles round them.

16. There is a certain noted Place, in the vast *Atlantick* Ocean, where a brisk *Levant* is absolutely the best Wind for a Ship that is to shape a due *East* Course, and yet she shall still go before it.

Answer, If the Place be *Eastward* of the *Levant*, a Ship may be carried by an *East* Wind round the *Globe* to it, provided some *East* Point be fixed; or where there is a violent Tide; as the *Gulf of Florida* may be meant: But the Quibble may lie in the Word *shape*; for an *East* Wind may be best for carrying her out of an Harbour, to sail to a Place on the *Eastern* Part of that Island or Continent; or it may mean the Streights of *Gibraltar*; for a brisk *Levant* raises the *Mediterranean*, in so much that the Passage thro' them is the safer, as 'tis to come into an Harbour, when High Water: Thus, if I mistake not, in the *East-India* Voyages, near or on the Line, a Wind from the *Levant* seems to be the only Wind to keep a Ship from being driven to the *African* Shore.

17. There are divers remarkable Places, upon the *Terraqueous Globe*, whose sensible *Horizon* is commonly fair and serene; and yet it is impossible to distinguish properly in it any one of the intermediate Points of the *Compass*, nay, or so much as two of the four *Cardinals* themselves.

Answer, Under either of the *Poles*, in which all the Points of the *Compass* meet in a Center, as aforesaid, in Paradox 5, 10, foregoing.

18. There is a certain Island in the *Baltick* Sea, to whose Inhabitants the Body of the *Sun* is clearly visible, in the Morning before he Riseth, and likewise in the Evening after he is Set.

Answer, This is occasion'd by Refraction, some of whose Properties are, 1. That oblique Rays out of a thinner Medium, falling on a grosser are refracted, or accede towards the

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the Perpendicular let fall from their Entrance. But 2^{dly}, Rays out of a grosser Medium into a thinner, recede further from the said Perpendicular. 3^{dly}, Perpendicular Rays are not refracted. 4^{thly}, The greater is the Refraction, the further the Rays are from being Perpendicular. Hence 'tis that the Sun and Stars Refraction is greater, the nearer they are to the *Horizon*, also the thicker the Atmosphere the greater the Refraction; as near the *Poles* and in the *Northern Seas*, as the *Baltic*. Refraction is useful in the first Discovery of Land upon Sea, raising the Tops of Mountains in the Air, to be seen several Leagues further off, than they would be were there no Refraction. This made the *Hollanders* in *Nova Zembla*, see the Sun rise some sixteen Days before they expected it, or would have seen it, had there been no Refraction. This also is the Reason why a Piece of Silver, which could not be seen in a Bason, yet being covered with Water, a thicker Medium than Air, appears visible: And also, why, if a Man would shoot a Salmon under Water, he must not aim at that Point of the Water, where the Ray of Sight enters, but a great Way on this Side of it; as, if the Salmon was in the Perpendicular let fall from the Point where the Ray of Sight enters the Water.

The ingenious *Lowthorp*, about 1700, gave ocular Demonstration of the Refraction, by making a Vacuum between two inclin'd Planes of Glass, by the Help of Quick-silver, thro' which an Object, viewed with a Telescope was seen, upon Re-admission of the Air, very sensibly to change Places according to the different Density thereof, See *P. Transf.* N^o 257.

19. There is a certain Village, in the Kingdom of *NAPLES*, situated in a very low Valley; and yet the *Sun* is nearer to the Inhabitants thereof, every Noon by three Thousand Miles and upwards, than when he either Riseth or Setteth to those of the said Village.

Answer, The Sun is nearer at Noon than at his Rising or Setting to the Inhabitants of any Part of the Earth, as well as *Naples*; and to any Place in the Parallel of Latitude where he is vertical at any given Time, he will be nearer by the Semidiameter of the Earth, which is three Thousand nine Hundred and eighty two *English* Miles: And when he is in
the

the Equinoctial, he will be nearer when on the Meridian than when in the Horizon, by the Radius of that Circle, which is the Parallel of Latitude of any given Place.

20. There is a certain Village, in the *South* of *Great-Britain*, to whose Inhabitants the Body of the *Sun* is less visible, about the *Winter* Solstice, than to those who reside upon the Island of *Iceland*.

Answer, This Village, perhaps, is near *Lewis* in *Sussex*, lying under an high Mountain; there, about the Time of the *Winter* Solstice, the Sun is but a small Time visible to the Inhabitants; or some Valley or Glin surrounded with Hills, in or near *Wales*, that in the *Winter* 'tis near Noon ere the Sun approach them, and then disappears presently; whereas in an open Place in *Iceland*, or on the Top of an high Mountain, there the Sun may much sooner and much longer appear, and the more because of the greatness of Refraction, which the grossness of the Atmosphere magnifies: Moreover, in Glins, near Mountains, 'tis observable, there is least Sun-shine, because Mists are more frequent.

21. There is a vast Country in *ÆTHIOPIA SUPERIOR*, to whose Inhabitants the Body of the *Moon* doth always appear to be most enlightned when she is least enlightned, and to be least, when most.

Answer, "The Light that falls upon any Body, being always in a reciprocal duplicate Ratio of the Distance from the Luminous Bodies" Hence it follows, that not only in *ÆTHIOPIA*, but in all Parts of the World, the Moon doth always appear to be most enlightned at the Full, when she's least enlightned, because she is then removed from the Sun farther than at the new Moon; by the Diameter of the Moon's Orbit, at which Time, tho' nearest to the Sun, she appears least enlightned to us, when she is, in Reality, most: Or *ÆTHIOPIA*, Interior or Superior, being situated near and under the Tropic of Capricorn, and hath Valleys surrounded with prodigious high Mountains, and the Terms, most and least enlightned may either respect the Moon's Body, or the Time of her shining.

1. If her Body, observe, that the Moon is as well enlightned by the Earth as the Earth by the Moon, is discovered by Telescopes

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Telescopes in the Hands of modern Philosophers ; and neither the Ancients did, nor Moderns do question, that both receive Light from the Sun : Wherefore, at the Full, when she seems most enlightned to any one Place, she is least, in respect of her self, because then, she receives only those Rays that come directly from the Sun : But at the New Moon, when she seems least enlightned to us, she is most in respect of her self, because she receives Light from the Sun, on that Side next to him, and Light from his Beams reflected from the Earth, to that Part of the Moon next us ; so at Conjunction, she is, in a manner, wholly illuminated in her self, and but half in Opposition.

2. *If it respect the Time of her Shining*, seeing 'tis Winter in *ÆTHIOPIA*, when Summer with us, & *e contra*, they have the longest Nights when ours are shortest, and the contrary ; wherefore, to them the Moon will be most enlightned, or shine longest, when to us least, and also most to us, when least to them.

22. There is a certain Island (whereof Mention is made by some of our latest Geographers) whose Inhabitants cannot properly be reckon'd either Male or Female, nor altogether Hermaphrodites : yet such is their peculiar Quality, that they are seldom liable unto either Hunger or Thirst, Cold or Heat, Joy or Sorrow, Hopes Fears, or any such of the Attendants of Life.

Answer, If Puppets, Insects, Stones, Animalcules, Birds, Fishes or Plants, by a Catachresis may be called Inhabitants, then may our Author mean the Island of Parrots, situate in *Terra Australis incognita*, or any uninhabited Island, discovered by our latest Travellers, where no other Inhabitants are, save such Plants, Fish, Stones, Insects and Animalcules.

23. There is a remarkable Place of the Earth, of a considerable *Southern* Latitude, from whose *Meridian* the Sun removeth not for several Days, at a certain Time of the Year.

Answer, 1. 'Tis doubtless under the *South Pole* ; but, 2. Taking Sun for Sun-shine, by a Metonymy, it may intend any

any Place beyond the *Antarctic Circle*; and then it will not mean that the Sun stands still in the *Meridian*, but that he enlightens it for so many Days as he is above their *Horizon*; and this is usual, when we say the Sun moves not from such a Wall or Dial for so many Hours: Thus, in Latitude sixty-eight Degrees *South*, the Sun shines upon its *Meridian* constantly for thirty Days.

24. There is a certain Place of the Earth, of a considerable *Northern Latitude*, where tho' the Days and Nights (even when shortest) do consist of several Hours; yet in that Place it's Mid-day, or Noon, every Quarter of an Hour.

Answer, Under the *North Pole*, for there every *Azimuth* is a *Meridian*, and the Sun's Course is nearly parallel to the *Horizon* all the Year.

25. There are divers Places on the *Globe* of the Earth, where the *Sun* and *Moon*, yea and all the *Planets*, do actually Rise and Set according to their various Motions, but never any of the fixed Stars.

Answer, Under the *Poles*, the Planets by their Motions, get *North* and *South Declination*, consequently Rise and Set, with relation to those two Places; but the fixed Stars keeping an exact Distance from the *Pole*, may be said never to Rise or Set, tho' their Motion, on the *Poles* of the *Ecliptic*, may be thought some small Objection to this Paradox: Or if by *divers Places*, be meant many, or more than two, he may intend any Place in *ENGLAND*, *DENMARK* or *GERMANY*, where Spheres are, or Pieces of artificial Clock-work, &c. shewing the Rising and Setting of the Planets, but none of the fixed Stars.

26. There is a very remarkable Place, upon the *Terraqueous Globe*, where all the *Planets*, notwithstanding their different Motion and various Aspects, do always bear upon one and the same Point of the *Compass*.

Answer, Under either of the *Poles*, for Reasons in Paradox

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dox 5, 10, 17, 23, 24, 25 ; for to an Eye, situate in the *North* or *South Pole*, all the Stars, however situate, will bear on the *South* or *North Point* of the *Compass*, because every *Azimuth* becomes a *Meridian*, the *Zenith* and *Pole* being but one and the same Point.

27. There is a certain noted Part of the Earth, where the *Sun* and *Moon* (*ipso tempore plenilunii*) may both happen to Rise at the same Instant of Time and upon the same Point of the *Compass*.

Answer. Under the *Poles*, for Reasons in the last, to which add Refraction, which raises the Object into and above the *Horizon*, when 'tis considerably under the same. See *Paradox* 18.

28. There is a certain Place, on the *Continent of EUROPE*, where, if several of the ablest Astronomers (the World now affords) should nicely observe the celestial Bodies, and that at the same Instant of Time; yet the planetary *Phases* and their various *Aspects*, would be really different to each of them.

Answer. Some say, that no one can observe all the Celestial Bodies at one and the same Instant of Time, either at the Center, or any Part of the Earth. 2. Others answer thus, if one of these able Astronomers shall nicely observe the Heliocentric Places of the Planets, another the Geocentric: their Phases and Aspects would be really different to each of them. Or, 3, This Paradox may respect the various Systems of the ablest Astronomers, whether *Ptolemy*, *Pythagoras* or *Tycho*, to each of whom the Planets would have both different Phases and Aspects, were they nicely observed in any Part of the World; because *Ptolemy* fixed the Earth in the Center, the Sun betwixt *Venus* and *Mars*; but *Pythagoras* and *Copernicus* place the Sun in the Center of all, and the Earth betwixt *Venus* and *Mars*, and *Tycho* blending both Systems aforesaid, borrows from each, but agrees with neither; he supposing the Earth in the Center of the Sun, Moon and fixed Stars, daily to revolve on its *Axis*, and the Sun in the Center of the other five Planets, revolving about the

the Earth in one Year. Or, 4. By the Word *Aspects* in this Paradox, respect may be had to the ablest Astrologers quartering and trisectioning, or various Ways of erecting their Schemes of the Heavens! Suppose

A B C D	{ following	Regiomontanus Campanus, Alcabitius, Ptolemy,	{ may put	Saturn Saturn Saturn Saturn	in the	11 12 10 10	and	Venus Venus Venus Venus	in the	9 9 8 8	{ How

Thus may *B* have a square mundane Aspect of *Saturn* and *Venus*, when *A*, *C*, *D* have a Sextile, & sic de cæteris. And this may be in any Place, where such Astrologers of different Judgments meet, whether they be Disciples of *Regiomontanus*, *Ptolemy*, &c.

Lastly, If *Celestial Bodies* mean, by a Metonymia signi pro re signata, the Planets in certain Spheres in *GERMANY*, viewed by several able Astronomers, at the same Instant of Time, their planetary Phases and Aspects would be really different to each of them, by Reason of their Parallax of Sight and Situation, one seeing some Point of the same Planet hid from the Sight of the other, and on a different Point of the Compass.

29. There is a large and famous Country, on the Continent of *AFRICA*, many of whose Inhabitants are born perfectly deaf, and others Stone blind, and continue so during their whole Lives, and yet such is the amazing Faculty of those Persons, that the Deaf are as capable to judge of Sounds as those that Hear, and the Blind of Colours as those that See.

Answer. The Blind and Deaf have Capacity to judge of Colours and Sounds, as well as those that See and Hear; tho' they want the Senses of Seeing and Hearing: Or because the Paradox refers us to the Continent of *AFRICA*, perhaps none of them have any Judgment in Colours or Sounds, as may appear by their harsh Jargon in Speech and Musick, and profound Ignorance and Stupidity in any Thing that is curious; as in *ÆTHIOPIA*, exterior, there be Cannibals, who are so extreme nasty and brutish, that they have

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have nothing, save the Shape of Men, to lay Claim to the Character of rational Creatures: They smear themselves with stinking Grease; their Cloak is a Sheep's Skin just flead, and their Ribbons and Stockings are the Guts which they frequently feed on, as well as Human Flesh; yea and themselves, tho' so brutish and swinish, serve, as good Pork to the *Cabons's*, a worse Sort of Cannibals, if possible.

30. There are certain People in *South AMERICA*, who are properly furnish'd with only one of the five Senses, (*i. e.*) that of Touching; and yet they can both hear, see, taste and smell, and that as nicely as we *Europeans*, who have all the five.

Answer, All the Senses are properly by the Touch: In seeing, the Object touches the *Retina*; in hearing the Sound touches the *Drum* of the Ear; in smelling the *Essuvia's* touch the *Sensorium*; in Tasting, the *Palate*, &c. Or tho' they may have them, yet (as in the last Paradox) they being so brutish, and not knowing them, neither the right Use or Exercise of them, they may be said, not to be properly furnish'd with them; like us *when asleep*, yet when taught they can use them as nicely, as we *when awake*; so they have them *in potentia*, as a Child, yet not *in actu*, as when grown up, before they be taught by others.

31. There is a certain Country in *South AMERICA*, many of whose savage Inhabitants, are such unheard of Cannibals, that they not only feed upon human Flesh, but also some of them do actually eat themselves, and yet they commonly survive that strange Repast.

Answer, If they don't eat (*their Meat*) themselves, who can eat for them, in such manner as to sustain their Life? or they may be such Brutes and Cannibals as to eat their Wives, Husbands or Children, which may be said to be Part of themselves, as being one Flesh and proceeding from them.

32. There is a remarkable River on the *Continent of EUROPE*, over which there is a Bridge, of such a Breadth,

Breadth, that above three thousand Men, a-breast may pass along upon the same, without crowding one another in the least.

Answer, The River *Guadiana*, betwixt *Andalusia* and *Portugal*, formerly call'd *Anas*, hides itself wholly at the Town *Medelina*, and at about thirty-two Miles Distance shews itself again; and *Alpheus*, a River of *ACHAIA*, runs under the Ground and Sea all the Way to *SICILY*, where, the *Grecians* say, it rises again, and is called *Arethusa*; because every fifth Year, it casts out the Dung of the Cattle that was thrown into *Alpheus*, at the Time of the Olympic Sacrifices; therefore the Land, over either of them, may not improperly be called a Bridge: Also in the County of *Warwick* there is such a Bridge: On a Common, near *Over Ichington*, is a Pool whose Stream entrencheth the Ground, and after an intricate Passage of half a Mile, cometh out again, and passeth along the Brook. Several such are also in the Province of *Connaught* in *Ireland*.

33. There is a large and spacious Plain, in a certain Country of *ASIA*, able to contain six hundred thousand drawn up into Battle array; which Number of Men being actually brought thither, and there drawn up, it were absolutely impossible for any more than one single Person to stand upright upon the said Plain.

Answer, According to *EUCLID*, a Plane can touch a Sphere only in one Point, called the Point of Contact and that Person only who stands to that Point; with respect to the Center of that Sphere can stand upright, and whereas the sensible Horizon changes, as oft as we change our Place, because of the Convexity of the Earth's Periphery.

See Euclid, by W. Whiston, Lib. 1, 19, and 3, 2, 16, 37, in their Consecrations.

And supposing each Man to stand, as Perpendicular as a Plumb-Line to his own *Horizon*, and seeing 'tis an undoubted Axiom, that all heavy Things tend towards the Center of the Earth, where all Perpendicular Lines, if extended, would meet.

These Things considered, I say, 'tis absolutely impossible for

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for two Men to stand Perpendicular, to the same Plane; without contradicting the Axioms aforesaid; for could they stand Perpendicular, then would they be Parallel to each other; and were Parallels extended to the Center of the Earth, they would never meet, as all Plumb-Lines so extended would.

'Tis true; this intellectual Truth is easily demonstrated to the Mind, tho' not so easily to be mechanically proved to the Eye; because the Height of a Man bears no sensible Proportion to the Earth's Semidiameter. This is the longer insisted on for the Sake of the following *Paradox*.

34. There is a certain *European City*, whose Buildings being generally of firm Stone, are (for the most Part of prodigious Height, and exceeding strong; and yet 'tis most certain, that the Walls of those Buildings are not Parallel to one another, nor Perpendicular to the Plane on which they are built.

Answer, All Walls are endeavoured to be built Perpendicular to the Tangent and point to the Center of the Earth; where they, if continued, would meet in a Point; but if extended to the Moon and Stars, would grow wider and wider asunder, the nearer they approached them; and consequently are not Parallels, which, if infinitely extended would never meet, nor part further asunder, but keep still the same Equidistance: Also in one Point only can a Perpendicular to the Earth be raised on a horizontal Plane, as appears by the last *Paradox*. But to be more particular; 'tis not improbable our ingenious Author might, in this *Paradox* intend the City of *Edinburgh* noted for strong, high, and Stone-Buildings; some being as is reported, fourteen Stories high, built on an Hill; and therefore the Walls are not Perpendicular to the Plane of the Hill, but to the Base of it; and the Walls are not parallel to each other, for the Reasons aforesaid.

35. There is a certain City, in the Southern Part of *China*, whose Inhabitants (both Male and Female) do observe almost the same Posture and Gate in Walking as we *Europeans*; and yet they frequently appear to Strangers as if they walk'd on their Heads.

Answer,

Answer, In CHINA (or any other Places, where the Inhabitants stand near the Sea) Strangers looking in it must see them, as tho' their Heads were downwards, by the refracted Vision; or CHINA being situate almost in opposite Meridians to us; and therefore to Strangers in Geography, to tell them there are People walking with their Feet towards ours, they will ask (according to the Appearance of the Thing to them) do they then walk on their Heads? For our own are uppermost, and their Heads must be under our Feet: Then whereas the *Globe* being round, all our Heads are next Heaven, and Feet next the Earth, and no upper nor under on the *Globe*, any more than on a Wheel in Motion.

36. There are ten Places of the Earth, distant from one another three Hundred Miles and upwards, and yet none of them hath either Longitude or Latitude.

Answer, The Places are said to be of the Earth, not upon the Earth; for Longitude and Latitude are reckoned on the Surface of the *Globe* only; so the *Axis* of the Earth, or any other imaginary Line, being above seven thousand Italian Miles will not only answer this *Paradox*; but instead of ten, if he had said twenty, it would have kept within the Possibility of the Demand.

37. There are two distinct Places of the Earth, lying under the same *Meridian*, whose Difference of Latitude is sixty Degrees completely; and yet the true Distance, betwixt those two Places, doth not really surpass sixty Italian Miles.

Answer, The two Places, are not meant on the Superficies of the Earth, as you may perceive by the Word of (and not upon) so the Places will be so near the Center of the Earth, as two Lines, supposed to come one from no Degree of Latitude, the other from sixty Degrees of Latitude, and to meet in the Center, may approach within the Distance of sixty Italian Miles. Or if the Places must be on the *Globe* of the Earth, we must distinguish between Latitude when apply'd to a Country, and when apply'd to a City; the last, is the Distance

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tance of that City from the Equator, *North* or *South*, the first is only the Breadth of a Country from *East* to *West* : Thus, the two Countries may be *Italy* and *Germany*, which lye under the same Degree of Longitude ; the Breadth, or Latitude of *Germany*, is said to be five hundred and ten Miles, and the Breadth or Latitude of *Italy*, is said to be an hundred and thirty four Miles, their Difference of Breadth, or Latitude, is three hundred and seventy six Miles, or above sixty Degrees ; and yet *Italy* is not sixty Miles distant from *Germany*, for they are parted but by the *Alps*.

38. There are also two distinct Places of the Earth, lying under the Equinoctial Line, whose Difference of Longitude is, completely eighty six Degrees ; and yet the true Distance, between these two Places, is not full eighty six *Italian* Miles.

Answer, As in the last, so in this, the Longitude of a City is its Distance *East* or *West* from the first Meridian ; but the Longitude, or Length of a Country, is its Distance from *North* to *South* ; thus, suppose the Isle of *St. Thomas*, whose Longitude or Length is not above a Degree and an half, and the Country of *ÆTHIOPIA EXTERIOR*, which is above ninety Degrees long, reckoning its Length down from *Nubia* to the Cape of *Goodhope*, and up all along the Coast of *Zanguebar* ; wherefore the Difference of Longitude or Length, may be said to be completely eighty six Degrees and an half, and yet the true Distance of the said Island, from the said Country, is not much above a Degree : Or the Places are not supposed on the Surface of the Earth, but nearer to the Center, where the Longitudes all coincide.

39. There are three distinct Places of the Earth, all differing both in Longitude and Latitude, and distant from one another two thousand Miles completely, and yet they do all bear upon one and the same Point of the *Compass*.

Answer, All Places, though they differ both in Longitude and Latitude, at what Distance soever, with respect to either Pole, bear upon the same Point of the *Compass* or they may be in the same Spiral Rumb, else understood as in the *Earth*,

Earth, and not upon it. For to any Eye situate under the
 $\left\{ \begin{array}{l} \text{North} \\ \text{South} \end{array} \right\}$ Pole, all Places, howsoever situated, will bear
 on the $\left\{ \begin{array}{l} \text{South} \\ \text{North} \end{array} \right\}$ Point of the *Compass* because every Azi-
 muth is a Meridian, and the *Pole* and *Zenith* coincide, as
 aforesaid.

40. There are three distinct Places on the *Continent*
 of *EUROPE*, equidistant from one another (they
 making a true equilateral Triangle, each of whose Sides
 doth consist of a thousand Miles) and yet there is a
 fourth Place so situated, in respect of the other three,
 that a Man may travel, on Foot, from it to any of the
 other three in the Space of one Artificial Day, at a cer-
 tain Time of the Year, and that without the least Hur-
 ry or Fatigue whatsoever.

Answer, By an artificial Day, is meant from Sun-rising to
 Sun-setting: Now beyond the Polar Circles, and nearer to
 the Poles, the Days are encreased from twenty four Hours to
 six Months, without Sun-setting under the Poles, in which
 Time, one may travel above four thousand Miles, and tra-
 vel only a Mile an Hour one with another.

Or suppose the three Places to be in *SWEDEN*,
NORWAY and *MUSCOVY*, where their Day is about
 two Months long near the Summer-Solstice, let the fourth
 Place be equi-distant from the other three: Now if the Side
 of an Equilateral Triangle be one thousand, the Radius of
 its Circumscribing Circle will be five hundred seventy seven
 Miles; and if a Man travel but ten Miles a Day, he may
 readily travel from the Center of the Triangle to any of those
 three Places in one such Day.

41. There are three distinct Places on the *Continent*
 of *EUROPE*, lying under the same *Meridian*, and
 at such a Distance, that the Latitude of the third sur-
 passeth that of the second, by so many Degrees and
 Minutes, exactly, as the second surpasseth the first;
 and yet the true Distance of the first and third, from
 the second or intermediate Place, is not the same by a
 great many Miles.

Answer,

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Answer, The oblate spheroidical Figure of the Earth may cause such a Difference. Or suppose *London, Paris* and *Bourbon*, all under the same brazen Meridian, equally different in Latitude; yet the Distance of *London* from *Paris*, will exceed the Distance of *Bourbon* from *Paris*, by near an hundred Miles; because *London* is about two Degrees *Westerly* off *Paris*, about the Breadth of the Brazen Meridian; whereas *Bourbon* and *Paris* are in the same Longitude, and consequently nearer, by almost two Degrees.

42. There are two distinct Places on the Continent of *EUROPE* so situated, in respect of one another, that tho' the first doth lie *East* from the second, yet the second is not *West* from the first.

Answer, If any two Places be in the same Parallel of Latitude, respecting the Rumb, the first may and must bear off the second *East* and *West*: and yet the second, respecting the Angle of Position, or the Bearing of one Place from the Zenith of the other, on the *Globe*, may be far short of being due *West*, as *Lisbon* in *Portugal*, and *Smyrna* in *Natolia*, are in the same Parallel of Latitude, *i. e.* thirty nine Degrees, and therefore, by the Rumb, they bear *East* and *West*. But on the *Globe*, *Smyrna* bears off the Zenith of *Lisbon* seventy five Degrees *North East*, and *Lisbon* bears off the Zenith of *Smyrna* eighty Degrees *South West*, which is evident from the *Globe* and Circle Sailing.

Note, A Rumb Line makes equal Angles with all Meridians on the *Globe*; and an equal Part thereof altereth the Latitude equally: But in the Circle of Position makes unequal Angles, *i. e.* greater Angles with all other Meridians than with that from which it was drawn.

43. There is a certain *EUROPEAN* Island, the *Northermost* Part thereof, doth frequently alter both it's Longitude and Latitude.

Answer, By *European* Island, may be meant either the Map of it, as *ICELAND*, whose *North* Part used to be set above the Arctic Circle, but now is below it, and nearer the *East*. Or the Island it self; then it must mean some floating

floating Island, as *Boethius* tells us, there is one in *Lomond*, the biggest Lake in *Scotland*; which also our ingenious Author mentions, as one of the Rarities of *Scotland*; in which Lake are also Fishes without Fins, and it is frequently tempestuous in a Calm: Or an Island, whose *North-Easterly* Part is overflow'd by the Sea; this will alter both its Latitude and Longitude.

44. There is a certain Place in the Island of *Great-Britain*, where the Stars are always visible, at any Time of the Day, if the *Horizon* be not over-cast with Clouds.

Answer, That Place may be some Coal-pit, Well, deep Cave, or high Chimney, or Dr. *Halley's Royal Observatory*; such as *Tycho* had at *DENMARK*; which was a deep Well or Dungeon, beset with Looking-Glasses, where he sat and observ'd the Stars in all Seasons.

45. It may be clearly demonstrated by the *Terrestrial Globe*, that it is not above Twenty Four Hours Sailing, from the River *Thames* in *ENGLAND*, to the City *Messina* in *SICILY*, at a certain Time of the Year; provided there be a brisk *North* Wind, a light Frigate, and an Azimuth Compass.

Answer, Nor twenty four Hours neither, if the Voyage be performed on the Globe, and the Time measured by its Hour Index; or if it mean the Tides sailing betwixt those two Places: Or because one may pass from *France* to *Italy* by Land, and the Sailing betwixt *Britain* and *France*, also *Italy* and *Sicily*, is not above twenty four Hours.

Or if by twenty four Hours, be meant the natural Day under the *Poles*, which is a whole Year, this Voyage may be perform'd more than once in that Time.

Or, Lastly, the Difference betwixt the *Julian* and *Gregorian* Account being eleven Days, whereunto add another, which makes twelve; a Time sufficient for such a Voyage; provided you have, still, a good Wind, light Frigate, and proper Instruments.

This may easily be demonstrated by the *Terrestrial Globe*, on whose *Horizon*, both Accounts are laid down.

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“ These (adds our Author) are the chief Paradoxical Positions, in Matters of Geography, which mainly depend on a thorough Knowledge of the *Globe*; and though it be highly probable that they will appear, to some, as the greatest of Fables, yet we may boldly affirm, that they are not only equally certain, with the (afore said) Theorems; but also we are well assured, that there's no Mathematical Demonstration of *EUC LID*, more infallibly true in itself, than is every one of them.”

Howbeit, lest some of the foregoing Solutions should not answer the Dignity of this Encomium or Character, hear what the same ingenious Author, who doubtless knew his own Sense best, acknowledges in his Preface.

“ If therefore these PARADOXES, above-mention'd, shall obtain the End propos'd (the rousing of the *Mind* to *Think*) it matters the less, if some of them, upon strict Enquiry, should be found to consist of equivocal Terms, or, perhaps, prove little more than a Quibble at the Bottom.” To which I subjoin, if any of the preceding Answers seem not sufficient, or satisfactory, I desire our Author's End may be still pursued: May it rouse the Mind of my judicious Reader, to *Think*, and offer a better; according to the Saying of the Poet, with which I conclude this first Part.

———*Si quid novisti rectius istis,
Candidus imperti; Si non, his utere mecum.*

Some PARADOXES added in this Edition, and some of them left unanswered for the Amusement of the Curious.

46. **T**HERE are two Places of the Earth, which bear directly North and South of each other, and their Distance is 100 Miles, but the true Course from one of those Places to the other is to sail 50 Miles due North, and 50 Miles due South.

Answer, These two Places must be each 50 Miles distant from one of the Poles, and both on one great Circle or Meridian

Moridian, but on different Sides of the Globe, that is, they must be Periœci to one another, differing in Longitude 180 Degrees, then suppose two such Places one on each Side the North Pole; the first 50 Miles of the Course will be due North, or directly towards the North Pole, the other 50 Miles will be due South or directly from the North Pole.

47. There is a Parallel of Latitude upon which a Ship may sail at the Rate of 16 Geographical Miles an Hour, and in 24 Hours, her Velocity measured in Degrees of the Equator, will be equal to the Velocity of the Sun on the 21st of June.

Answer, By being equal to the Velocity of the Sun, is only meant that the Ship may sail round a smaller Circle of the Earth or Parallel of Latitude, while the Sun appears to go round the Earth, or in Reality while the Earth turns round on its Axis, that is in 24 Hours; and about the Latitude of 89 Degrees (if there were no Land, nor extreme Cold and Mountains of Ice to hinder it) a Ship might sail quite round upon that Parallel, at the Rate of 16 Miles an Hour, so as to arrive in 24 Hours at the Place of her setting out.

48. There is a certain Place of the Earth from which two Ships may depart on one and the same Day, and on the same Hour and Minute, and upon one and the same Point of the Compass, may both continue to sail at the same Rate for the Space of 24 Hours, and yet in 24 Hours Time they will be distant above 200 Miles.

Answer, The Place may be at either of the Poles, for going from the Pole there is but one Point of the Compass from the North Pole South, and from the South Pole North, see Paradox 10. And two Ships may sail from the North Pole, yet two different Ways, directly from one another, then altho' going at the same Rate, and on the same Point of the Compass, if each Ship hath sailed 100 Miles, their Distance will be the Sum of what both have sailed, viz, 200 Miles.

49. There are two Places lying in the *Torrid Zone*, that are not above 60 Miles asunder, but if a Ship sail from one to the other on one particular Point of the Compass; the Difference of Time between these two Places will be found to be above 23 Hours.

Answer, We may suppose these two Places A and B, A lying 60 Miles or 1 Degree East of B, and consequently scarce differing in Time 4 Minutes, yet if a Ship instead of sailing from B towards A Eastward, should sail directly Westward, the Distance sailed would be 359 Degrees, and above 23 Hours Difference in Time, altho' the shortest Distance between the two Places, would be only 1 Degree.

50. There are certain Places where a Sound being made, will not be heard by a Person at a certain Distance from it; tho' at the same Time it will be very plainly heard by another Person, who is twice as far from it; and each having the like Sensation or Faculty of Hearing.

Answer, In any hollow Tube or Pipe of a considerable Length, a Person placed at the Middle of it, can't hear the Sound, but one placed at the other End will hear it distinctly, because the Body of Air proceeds towards that Part where the least Resistance is: Or it may be in an elliptical-arched Vault, where a Sound being made at one of the Focuses, will be very plainly heard by a Person at the other Focus, tho' a Person in the Middle may not hear it; the Reason is all the Air that is struck against the Vault, will be reflected in an infinite Number of straight Lines, which all terminate at the other Focus, with Angles of Reflection equal to those of Incidence.

51. There is a certain Place of the Earth, where if a Man should try the Experiment, he would be able to support and bear the Weight of twelve hundred Weight of Lead, or any other Metal.

Read Paradox 3, which will help the Reader in the Solution of this.

52. There

52. There are 24 Places on the terraqueous Globe, in which all the 24 Hours of the Day do exist at the same Time, and yet the Distance of any two of these Places does not exceed 60 Miles.

53. There is a certain Parallel of Latitude upon which a Ship may sail round the Globe, and may all that Time observe the Body of the Sun without his being above the Horizon (allowing the Sun's Declination to remain the same during the Voyage.)

54. There are two remarkable Places on the Face of the Earth, whereon two Men may be placed at one and the same Time, (that is one in each Place) and if in case either of them should have a Mind to remove himself further from the other by travelling, 'tis plain that instead of going further from him, he would certainly move so much nearer to him every Step he goes.

55. There are three Places or Parts on the Surface of the Globe, that actually form a right angled Triangle with two equal Sides; and yet the readiest Way of travelling or sailing from the first to the second, and from the second to the third, is always to steer one and the same Course.

56. There are two Places equally distant from *Paris*, the one lies directly East from it, and the other West; yet each of these two Places is actually farther distant from *Paris*, by above 100 Leagues, than they are from one another.



P A R T II.

NEW
PARADOXES
SOLV'D.

57. **I**N what Degree of Latitude
Does that soft Female dwell,
Who, upon certain Days, might view,
If she observeth well,
The Morning Sun o'th' self-same Point
Of Compass twice to be,
Likewise his Evening Azimuth
Twice in the same Degree.
Tell me sweet *English* Ladies for you are
Than her more charming far, and far more fair.

Answer, Between the *Tropics*. See Paradox 12.

58. In the *Atlantic* Ocean, from our Shore
Distant five hundred Leagues, or little more,
Lie the *Canary* Isles, blest with good Air,
Sweet whistling Birds, rich Wines beyond compare,
A Moun-

A Mountain, the World's Wonder, situate there,
 One of the highest in this earthly Sphere;
 By us 'tis call'd the *Teneriffa's Pike*,
 Whose lofty Head i' th' Atmosphere's so high,
 That it surmounts all grosser Clouds o' th' Sky;
 Three Degrees and an half you may it ken,
 Or (what's the same) two hundred Miles and ten;
 For the Refraction, Angle you may make,
 Allowance (what is thought but meet to take)
 Thirty-five Minutes, just of a Degree:
 Now I demand what Height the Pike must be.

Ans. 4.28 Miles high.

59. I have twelve Times seen *Bissextile*,
 Pray tell how that can be,
 Since twelve times four make forty eight,
 And I'm but forty three.

Answer, If a Person be born on the 29th of February, and travel *Westwards* the *Globe* about, he may see twelve *Bissextile* Years before he be completely forty four Years of Age, if he was born in a *Bissextile* Year.

60. A Golden Ball shall weigh two Pounds in *Troy*,
 Where from th' *Æquator* ten Degrees doth lie;
 But at *London* a different Weight is found,
 Of that small Ball, which difference pray expound.

Answer, The Earth is not exactly round; but its Diameter at the Equinoctial Circle, is, to its Diameter thro' the *Poles*, as six hundred ninety two to six hundred eighty nine; therefore, according to the incomparable Sir *Isaac Newton* the Proportion of Gravity, betwixt the *Æquator* and *Poles*, is as five hundred to five hundred and one, and the Increase, near as the Square of the right Sine of the Latitude; and that the Ball would weigh more at *London* than at ten Degrees Latitude, by thirteen Grains.

This then is (I presume) occasion'd from the Earth's oblate Figure, and the Diminution of the centripetal Force

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or Gravity, which is universal, 1. In every single Particle of Matter. 2. As to its Extent. 3. As to all kinds of Bodies. 4. As to Time. 5. As to Quantity of Matter. 6. In a duplicate Proportion to their Distances.

61. *Dis quibus hoc Animal Terræ nascatur in Oris;
Masculus est mater cui Mulierque pater.*

Answer, Progenitos vidi numerosos vere Gyrinos
Hæc rana, hic Bufo, Mater hic, illa Pater.
A Tadpole, young Frog, or Toad.

62. *Leander* to his *Hero* writ, and she
As oft writ back, to shew her Constancy;
When with them both the Post three Times had been,
They had no more than each a Letter seen.

Answer. The Paradox means with both not each three Times: The first Post took *Leander's* Letter, second *Hero's* Answer, and third brought it to *Leander*.

63. The Day that I was born, my Father he
Laid by five Pounds, and said it was for me;
And when my Birth-Day came, he never fail'd
To add five Pounds, (his Love so much prevail'd)
At twenty four, and upon my Birth-Day,
I wedded was, my Portion he would pay,
Just thirty five Pounds (I full twenty four).
How comes it then my Portion was no more.

Answer, The Person was born in *Leap-Year*, on the 29th of *February*.

64. A certain Mount in *Devonshire* doth stand,
Whose lofty Head o'erlooks the neighb'ring Land;
And such is the known Property o'th' Hill,
That if a Vessel you with Liquor fill,
At the Hill's Top, or Vertex of the Place,
It holds less than if filled at the Base:

Now

Now what's the Cause of this Deficiency,
Pray let me know in the next Diary?

Answer, Water has its Surface always of a spherical Figure, and that farthest from the Earth's Center is least Swelling, and consequently holds least above the Brim of the Vessel: The Top Diameter of the Vessel being the Chord of a greater Circle, on the Top of an high Hill than at the Bottom, which is a somewhat less Circle, and consequently more Convex, will therefore hold more above the Brim, at the Base, than at the Top of the Mountain.

65. When 'Tyrant Noll, at fatal *Worc'ster* Fight,
His Crew harangu'd, against both Law and Right,
His quaint numerique Voice no two did hear,
Tho' several thousand Miscreants were there;
For ev'ry Man, and ev'ry several Ear,
Did not the same but distant Voices hear.

Answer, Sound being efflated in Concentric Circles as a Stone falling into Water, moves it all round so that Part of the Circle, which touch'd one Man's Ear could not touch another's, who could not be in the same individual Spot of Ground.

66. By what Means may I know most certainly,
That two Men in the World there are,
Whose Heads of Hair, (if numbered they be)
Are equal to a single Hair;
Altho' some Millions on each Head there were.

Answer, If the Number in the World, do exceed
The Number of Hairs that are on a Man's Head,
You may safely affirm then, that two Men there are
That have the same Number to a single Hair.

To explain and prove the Truth of this Hypothetical Proposition; that if there be more Persons in the World than the Number of Hairs on the Head of any one alive, then must there be two Men in the World, the Number of

34 *New* PARADOXES solv'd.

Hairs of one of whose Heads, is exactly equal (to a Hair) with those on the other's Head.

Suppose a very small Number of Men, for Instance eight, and the Hairs on none of their Heads exceed six; the same Consequence will follow by the same Ratiocination, as if you made Use of a greater.

Next, Suppose, one of these eight has but one Hair, if any other of the seven have only one Hair, we have already found out what we desired; if not, set this Man by, and out of the seven remaining, chuse another, which we suppose has two Hairs; now if any of the other six hath two Hairs, and no more, we have what we sought for; but if not, set this Man aside, and take another, out of the six remaining Men, which we suppose has three Hairs; if then any of the other five has got three Hairs, as well as he, our Enquiry is at an End; if not, set him aside, and chuse another out of the five, which we suppose has four Hairs; if any of the other four should chance to have four Hairs, then have we two Men that have each an equal Number, the Thing sought; if not, then they all four must have five or six Hairs; for beyond six no Man can have: Then put this Man by, and take a fifth, whom we suppose to have five Hairs: now if any of the other three have five, we have our Desire; if not, then it follows, that the three remaining Men, must of Necessity, have each Man six Hairs; for before we have proved that they had neither one, nor two, nor three, nor four, nor five, and therefore they must have six, beyond which they cannot exceed.

Now, if instead of supposing the first Man had one Hair, you had supposed he had six, five, or four, &c. you would by the same Way of Arguing, come at last to the same Conclusion.

67. *Phyllis*, the shy and scornful fair,
Was by brave *Strephon* held most dear,
But still, as he prest on his Joy,
She grew more malapert and coy;
And when he talk'd of Marriage to her,
She got more distant from her Wooer.
But what he su'd for, thus, in vain,
He did by Accident obtain;

For

For walking with his *Phillis* dear,
 One Afternoon to take the Air,
 In a vast Champain Country, where
 Nor Hedge, nor House, nor Tree were near,
 When straight dark gloomy Clouds appear,
 Which did presage a Storm was near.
 Anon (no Shelter being nigh)
 It rain'd and blow'd impetuously :
 Which made the shy Dame him invoke,
 To shelter her with his long Cloke.
 Soon after this the Storm grew higher,
 Which made the Nymph cling still the Nigher :
 Then roar'd around them Peals of Thunder,
 As if the Earth had burst asunder.
 This made the trembling Maid embrace,
 And in his Bosom shroud her Face.
 The Swain, tho' almost stunn'd with Fear,
 Being thus warmly clasp'd by's Dear,
 Took Courage and to her thus spoke,
Phillis, I all the Gods invoke,
 To witness that my Passion's true,
 And would forego the World for you ;
 No Flattery I need pretend,
 For surely now the World will end.
 Oh *Strepbon* ! (cries the trembling Fair)
 My Thoughts I'll tell you without Fear ;
 I Love as much, as dear as you,
 But Pride forbids what Love did sue ;
 And if this dreadful storm blow o'er,
 I ne'er will persecute you more.
 Then did they intermingle Kisses,
 A sure Presage of future Bliss.
 Straightway the Heav'ns began to clear,
 And Joy succeeded now their Fear.
 This was, as I do well remember,
 About the fifteenth of *December*,
 They then agreed to be in Wedlock join'd.

The

36 *New* PARADOXES solv'd.

The longest Day he in the Year could find;
And in the following Week the Marriage was,
Pray tell me now, how this could come to pass.

Answer, From Noon to Noon, *Astronomers* do say,
Are not just twenty four Hours ev'ry Day,
But longer some, some sooner haste away.
Good *Pendulums* as I do well remember,
Some Days about the twentieth of *December*,
The Space of thirty Seconds, measure more
In Number than they did the Day before;
But no Days else, which plainly make appear
That these the longest are in all the Year.
Strephon rejoyc'd, that he so soon had found
The Day on which his nuptial Joys were crown'd,
Fair *Phillis*, too, transported with Delight,
No lets rejoyc'd it prov'd the longest Night.

Some Reasons follow, serving to explain the foregoing Solution.

1. If the Sun or Earth moved a'long the Equinoctial with a constant, uniform and equal Motion, and were always equally distant from each other, the Days would be always exactly twenty-four Hours long.

2. The Sun moves not in the Equinoctial but in the Ecliptic, and if we suppose him to move equally, that is his diurnal Motion to be every Day the same; yet by Reason of it's Obliquity, equal Arches of the Ecliptic will not answer to equal Arches of the Equinoctial, which is one Cause of the Inequality of natural Days.

3. The Sun doth not move with a constant, uniform, equal Motion in the Ecliptic, but sometime faster and sometimes slower; because it moves in an Ellipsis; and in going one Half of it, spends eight Days more in *Summer* than in the *Winter* Half-Year. Therefore it unavoidably follows, that the Days are unequal, and not exactly twenty four Hours.

68. A Landed Man two Daughters had,
And both were very fair,
He gave to each a Piece of Land,
One round the other square:

At

At twenty Shillings an Acre, just,
 Each Piece its Value had,
 The Shillings which did compass each,
 For it exactly paid.
 If cross a Shilling be an Inch,
 (As it is very near)
 Which was the better Fortune, the
 That had the Round or Square ?

			<i>l.</i>	<i>s.</i>	<i>d.</i>
Answer, The Value of the	{ square round }	Piece is	250905	12	0
			197060	12	7½
Difference			53844	19	4½

The Algebraic Process,

The Perches English Measure.

In the Square Piece.

a = Number of Shillings that purchased it. a = Number of Inches about the 4 Sides. n = Number of Inches in a square Acre = 6272640. f = Number of Shillings that purchased an Acre.

Then $\frac{a}{4}$ = one Side which squared gives $\frac{aa}{16}$ which are the

square Inches in the Close this divided by n gives $\frac{aa}{16n}$ the

Number of Acres, which multiplied by f gives $\frac{aaf}{16n} = a$ the

whole Value of the square Piece in Shillings, and being re-

duced gives $a = \frac{16n}{f} = 250905 \text{ l. } 12 \text{ s. } 0 \text{ d.}$

In the round Piece.

a = Circumference in Inches. a = Number of Shillings that purchased it. d = Diameter of the Circle = 1. c = Circumference of said Diameter 3.14159.

Then

Then say,

As c to 1 :: $a : \frac{a}{c} = d$. Then $\frac{1}{2}$ Circumference to $\frac{1}{2}$ the

Diameter gives the Area. $\frac{a}{2} \times \frac{a}{2c} = \frac{aa}{4c}$ Area.

This Area divided by n , and multiplied by f , as in the former, gives the Purchase in Shillings, viz.

$$\frac{aaf}{4cn} = a \text{ which reduced is } a = \frac{4nc}{f} = 197050 \text{ } l. \text{ } s. \text{ } d. \text{ } 12 \text{ } 7\frac{1}{2} \text{ nearly.}$$

69. Suppose a round Ball for to move in the Air,
In a certain Proportion, which I shall declare ;
Let the first Hour be twelve Miles, the next to move
And so in Proportion from whence it began, (ten, }
As twelve is to ten. Now try if you can
Tell the Miles it will move, suppose it to be
Continued in Motion to Eternity.

Answer. The Ball that is moving *Eternally* so
In Proportion of twelve to ten justly will go,
Threescore and twelve Miles, and no more, I declare, &c.

The Reason of this Paradox is, that in infinite Geometrical Progression, if the Proportion do continually decrease, the last or least Term will be infinitely small, or, in Effect, nothing, and so produce a finite Number.

Suppose A = first or greatest = 12 it will be $\frac{AA}{A-B} = \text{Sum}$
 B = second Term = 10

of all the Terms = 72.

70. If, in one Second's Time, an Iron Ball
Did five and twenty *English* Half-Foot fall :
How long must be the Time it then must take
A Journey of ten thousand Miles to make?

Answer;

Answer, I think the Time in which the Iron Ball,
If gently dropt, ten thousand Miles will fall,
Must be allow'd in Minutes thirty four,
And Seconds nineteen, neither less nor more,

But it falls 10000 *Irish* Miles in thirty eight Minutes, 38 Seconds.

This depends on the following Proposition, that the Acceleration of the Descent of heavy Bodies, are as the Square of the Times; the Reason is, the Action of Gravity being continued in every Space of Time, the falling Body receives a new Impulse equal to what it had before, in the same Space of Time, received from the first Power.

Thus, suppose in the first Second of Time a Body hath acquired a Velocity, which, in that Time, would carry it thirty two Foot (and were there no new Force, it would continue to descend, at that Rate, with an equable Motion) but, in the next Second of Time, the same Power of Gravity, continually acting thereon, superadds a new Velocity equal to the former; so that at the End of two Seconds, the Velocity is double, to what it was at the End of the first.

Hence, then, the Question is easily solv'd; for turn the Miles into Feet 52800000 and divide it by 12.5, the Quotient is the Square of the Seconds the Body will be falling (*viz.* 4224000) the Square-Root whereof, gives Seconds (2059) and dividing by 60, gives Minutes, namely 34 and 19 Seconds, a little above half an Hour.

71. Before my Father was begot,
I'm sure I was begotten
And born before my Mother,
They are both dead and rotten:
And I am lying in that Bed
Where I got my Grandmother's Maidenhead.

Answer, Adam, I know, was ne'er begot,
And Eve of him was made,
And since by him they brought in Death;
They both, long since are dead,
'Tis certain, Abel was begot
Of those his two said Parents,
He dy'd by Force, and was the first

That

40 *New* PARADOXES solv'd.

That yielded to Death's Warrants :
Therefore he got the Maidenhead
Of's Grandmother, the Earth,
Being laid therein the first that was,
Tho' not the first by Birth.

72. I. As I was musing all alone,
What Paradox to pitch upon,
To entertain the Fair,
Within my Study flies a Bee,
Whose Wings made pretty Melody,
As ever I did hear.

II. Pleas'd with the Noise, I drew more nigh,
When instantly came in a Fly,
That charm'd me with her Sound;
The then united Tones produc'd
A perfect fifth as e'er was us'd,
Or could by Art be found.

III. The nimble Fly's Wings quicker were
Than those of her Competitor,
As may by this appear;
For an acuter Tone they made,
And in a sharper Key they play'd,
(Which made the Matter clear)

IV. If in a Minute's Time, thought I,
The nimble Wings of this same Fly
Ten thousand Beats did go:
What Number then must be the Swings
In two Hour's Space of the Bee's Wings?
Is what I fain would know.

Answer, Believe me, Sir, the little Bee,
With her harmonious Wings,
Did make exact, in two Hours Space,
Eight hundred thousand Swings.

The

The Foundation of this depends upon the Division of a Monochord, &c. Divide the String of a Viol into three equal Parts, and then strike the whole String (and observe the Sound) stop the String again, in one of the third Parts, and strike the Length that hath two Parts of the whole open; it will sound a perfect Fifth to the former Tone; so that the Proportion is as three to two; so is the Diapason to the Diapente, or the Musicians Eighth to their Fifth: So that the Paradox is easily answered; for as three to two, so is the Number of Vibrations that the Fly makes in two Hours, to the Number which the Bee makes in the same Time, viz. 300000.

73. I once essay'd (but 'twas in vain)
To win the Prize propos'd,
How'er I'll venture, once again,
'Cause merrily dispos'd.
The Mark whereat I now do aim,
The promised Reward,
Eggs me to play a forced Game,
And draw my only Card;
Astonishing it sure must be
As Paradox e'er was,
And thro' Surprise you scarce can see
How it should come to pass;
That I, the only Offspring, then,
Was marry'd to my Mother,
And yet she never marry'd Man,
Nor ever took another,
Nay, still a stranger Thing you'll find,
That when I wedded was,
I then was of the Female kind,
My Mother was the Mas;
Yet the most fruitful Wife ne'er had
So many Sons as I;
'Tis hard methinks, to be conceiv'd,
Tho' spoke without a Lye.
But know, the Cream o'th' Jest is here,
No Body was my Father;

Then

42 *New* PARADOXES solv'd.

Then wonder, yet, how't may appear
That ever I had Mother.
How could it ever happen so,
I'll have you all to guess,
And yet, perhaps, you can't find who
My loving Husband was.
Here, Ladies, you may ruminate,
And still remain in Doubt,
Which, if you can't investigate,
I'll dare to make all out.

Answer, Your Paradox must needs surprize
And much delight the Fair,
I think you merit well the Prize,
For 'tis beyond Compare,
Astonish'd I found out at last
Your Meaning must be *Eve*,
Being taken out of *Adam's* Wasse
Did Female shape receive,
The only Offspring then she was
And *Adam* was her Mother
She Woman was, and he the Mas
Yet was he not her Father,
A fruitful Wife she was, 'tis plain
Unto her Husband *Adam*;
Her eldest Son we read was *Cain*
God knows a very bad one,
Your Paradox thus I've explain'd
And think it is an hard one,
The Truth I hope, I have obtain'd
If not, I beg your Pardon.

74, Walking the other Day, to take the Air,
(Bright shone the Sun, the Weather very fair)
At Distance I a dismal Cloud did spy,
Which (as methought) against the Wind did fly.
While I upon my Watch did look, to see
How Time did pass away, lo, instantly
A dreadful Flash of Light'ning pierc'd the Cloud,
Just fourteen Seconds, after which, aloud

The

The Thunder roar'd, now I inform'd would be,
How many Feet the Cloud did burst from me.

Answer, When Heat and Moisture, are in one conjoin'd,
And sable Mountains chac'd before the Wind,
When two Contraries were together pent,
Their inbred Jars, soon shew'd their Discontent.
Then mighty *Jove*, to scourge their Mutiny,
Bombards their Fort with his Artillery ;
For when by Force th' embodied Cloud is rent,
A Peal of Thunder shakes the Firmament.
See here the Distance when that Rupture brake
When angry *Jove* thus to his Creatures spake,
Hush, cease this Rage. They straight are calm and still,
They all obey, and wait upon his Will.

According to Sir Isaac Newton, Sound flies 968 Feet in a Second ; wherefore $968 \times 14 = 13552$ Feet, or 2 Miles, 4 Furlongs, 352 Feet, English Measure.

Perhaps it may not be unwelcome to the Reader to deliver some Observations concerning *Sound*, and the *Progression* of it.

Sound is produced by the little Vibrations, which the Parts of the sonorous Body occasion in the Air ; and the *Strength* or *Weakness* ; in Proportion to the Quantity of Air struck, and the Strength of the *Vibration*.

Mr. *William Derham*, F. R. S. observes there is a considerable Difference in the Accounts given by good Authors about the Velocity of the Motion of *Sound* in a *Second* of Time, as followeth.

Sir *Isaac Newton's* first Edition of *Mathematical Principles*, gives 968 Feet in a Second of Time.

His second Edition corrected	_____	_____	1142
<i>Francis Roberts</i>	_____	_____	1300
Mr. <i>Baillie</i>	_____	_____	1209
Dr. <i>Walker</i>	_____	_____	1331
Mr. <i>Flamsteed</i> Astronomer Royal	_____	_____	} 1142
Edm. <i>Halley</i>	_____	_____	
Mr. <i>Derham</i> , F. R. S.	_____	_____	
<i>Florentine Academy</i>	_____	_____	} 1185
Royal Academy at <i>Paris</i>	_____	_____	
			This

44 *New* PARADOXES solv'd.

This Diversity proceeds, probably, from not using good Pendulums, but *Strings* and *Plummetts*. 2d. From disregarding the Winds. 3d. Distance betwixt *Sound* and *Observation* too short. And the Difference betwixt the three last being so small, might arise from using Pendulums equally good, and Experiments equally large.

The same worthy Author, by manifold Experiments, and repeated Observations, found no Difference, whether the *Gun* was fir'd towards or against him, in the Velocity of the *Sound*, nor in any different Elevation, nor in different Quantity, or Strength of Powder (tho' it did in Strength of Noise) neither betwixt Day or Night, Clear or Cloudy, Winter or Summer, Rain or Snow: All kinds of *Sounds* came in the same Time to his Ear, from the same Distance, whether tense or strong, languid or weak.

By very accurate Observations, he found the Motion of *Sound* to be equable in all Respects; that is, an *English* Mile in 9 half *Seconds*, 2 Miles in 18, 3 Miles in 27. &c. And he is confirmed in the Belief, that *Sound* moves the nearest Way, and its Velocity equal in Acclivities or Declivities, and that Difference of Climates or Weather, makes no Difference in the Velocity, though thick, cloudy or snowy Weather, did dull the Noise or Sound.

But I know not why Winds might not so affect *Sound*, that is, by conspiring with its Motion, advance it to 1200, or retard it by its being contrary, that it may not move above 1100 in a Second of Time.

The Use of all this may be to measure the Distance of Thunder, Forts, Batteries, or Ships at Sea, &c.

Any *Space* or *Distance*, proposed to find how long *Sound* will be flying that Distance; say,

As 1142 : is to 1 :: so is the Distance in Feet to the Time in Seconds.

Any Time proposed to find the Space or Distance that a Sound will fly in that Time, say,

As 1 : is to 1142 :: so is the given Time in *Seconds* to the Distance in Feet.

From what has being said, we may conclude, that *Sound* moves 1142 Feet in one *Second*, 8 Miles in 37 *Seconds*, 13 Miles in one Minute *Fere*, and near 780 Miles in an Hour.

And if we number 10 *Seconds* between the Fire of the Cannon seen and the *Sound* heard, it is manifest that the Gun is 11420 Feet distant, or somewhat more than two Miles.

As

As likewise, if 5 *Seconds* pass betwixt one seeing the Flash of Lightning, and hearing the Thunder, we may reckon the Thunder Cloud is about 5710 Feet, or a little above one Mile distant from us.

75. Enflam'd in Love and wrapt in Extasy,
Encircled in *Eliza's* Arms I lay ;
When envious Chance did our sad Parting cause,
Against both Nature's and Affection's Laws ;
But our next Meeting, we did then assign -
Seventy eight hundred Beats and twenty nine
Of a nice Pendulum, whose Length I see
Twenty five Inches three Eighths exact to be.

Assist me quickly, oh you Sons of Art,
You who have felt the Sting of *Cupid's* Dart,
You who to Tenderness and Pity move,
And know the Pangs of disappointed Love ;
For if, too soon or late, I chance to go,
Despair and Ruin certainly ensue :
Tell me the Hours and Minutes, I implore,
Or I shall never see my dear *Eliza* more.

Answer, One Day as I was in a musing Vein;
My roving Fancy did me entertain
With Thoughts of Love, which did the Time beguile,
And great Delight attended me the While.
Straightway I struck into a verdant Plane
To meditate, and ease my troubled Brain ;
There I espy'd a Grove most rich of Shade
Where wanton Birds harmonious Musick made :
All Things rejoyc'd in this most lovely Green,
Nature, in full Perfection, here was seen,
I plac'd myself under a spreading Tree,
Methought it was a charming Canopy,
Under this pleasant Shade *Eliza* sweet,
And her dear Lover, did together meet ;
Where he oft lay encircled in her Arms,
In Love-Transports, amidst a thousand Charms ;
But envious Chance did separate these Friends,
Who hope next Meeting will make them amends.

Ah!

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Ah ! cruel Fate, to cross poor Lovers so,
 Methinks I feel the Pain they undergo,
 Caus'd by that Traytor's Absence, in each Breast
 With Sighs and Tears which cannot be express'd.
 But least a Disappointment he should find
 In their next Meeting, which they both assign'd,
 To ease his Pain, it doth my Pity move,
 Who know the Pangs of disappointed Love.
 In his *Eliza's* Arms let him be blest,
 And in her pretty panting Bosom rest ;
 The Time is short, which if they chance to miss,
 It puts an End to all his Earthly Bliss ;
 Like a dear Lover, Love my Mind inspires,
 And his hard Case a Tenderness requires :
 How long it is e're he *Eliza* met,
 In this most pleasant Shade, I find complete
 To be one Hour, with Minutes forty four
 And Seconds fifty six, nor less nor more.

76. My Grandfire and my great Grandfire
 I'm sure conceived were
 Both in one Instant, at one Time
 First breathed in the Air.
 My Grandfire did no sooner breath,
 My Father did they same,
 Great Grandfire my Father begot
 Before my Father came.
 Into this World, where he did meet
 With Troubles, not a few,
 My Family it did decrease,
 I did the same renew.
 My Grandmother and Sister too,
 Conceived me, both as one :
 My Aunt and Sister, in like Case,
 Brought fourth another Son
 Tho' Grandmother and Mother too,
 Did bear me as a Son.
 My Grandmother transformed was,
 Before my Life begun

Though

Though thus transformed, suffered Death,
Josephus doth relate,
 Hundreds of Years after my Birth,
 He saw it in that State.

Answer, Your Paradox I must commend,
 Ingenious Mr. *Lover*,
 And though 'tis difficult, intend
 Solution to discover.

'Tis *Moab*, who was Son of *Lot*,
 Your Paradox must answer,
 Which of his Daughter was begot
 If this won't do, I can't, Sir;
Lot, Grandfire and Great Grandfire was
 To *Moab* and to his Brother,
 From hence, I think it comes to pass,
 'Tis true you mean none other;
 No Wonder they conceived were,
 (His Sire and Grandfire too)
 Both in one Instant, breath'd i'th' Air
 Together, as you shew,
 Great Grandfire *Haran* did beget
 His Father, *Lot*, we read,
 In *Ur* of the *Chaldees*, he yet,
 Long e're *Moab's* Birth was dead:
 Thus in this World, poor Lad did meet
 With Troubles manifold,
Sodom being burnt, he did retreat,
 And dwelt in a strong Hold:
 Laid in the Cave, Being drunk with Wine;
 Begot *Moab* and his Brother,
 Of's Daughter, who as you define,
 Was Sister and Grandmother.
 Thus Grandmother and Mother too;
 Did bear *Moab* as a Son.
 His Grandmother, *Lot's* Wife was dead,
 E'er *Moab's* Life begun;
 She was transformed into Salt,
 The Scriptures plainly say,
 Looking to *Sodom* was her Fault,
 She God did disobey;
 This Pillar fixed on the Earth,

Josephus

48 *New* PARADOXES solv'd.

Josephus doth relate,
Hundreds of Years after *Moab's* Birth
He saw't in the same State.

77. *Christians* the Week's first Day for *Sabbath* hold,
The *Jews* the seventh (as they did of old)
The *Turks* the sixth (as I have oft been told)
Now, Good Sir, pray tell to me,
How it is possible this Thing can be,
That ever a *Christian*, *Jew* and *Turk*, these three,
Being altogether, in one Place may,
In and upon one and the self same Day,
Have each his own true *Sabbath*, tell I pray.

Answer, From the Place of the *Jew's* Abode let the other
two set out,
The *Christian East*, the *Turk West*, and sail the Globe about;
Then with the *Jew* they will agree when they again do meet,
And all upon the *Saturday* will their true *Sabbaths* keep.

78. Walking one Evening on the Sandy Shore,
Where Shell-Fish breed, and Seas for ever roar,
I saw a Ship dance on the rolling Tide,
With curling Smoke advancing from her Side;
Which for some Moments my dull Sense employs,
Before I heard the thund'ring Cannon's Noise.
Then from my Fob Time's Register I drew,
And from her Sides a second Light'ning flew;
Full fourteen Seconds of swift Time expir'd,
Before the Sound my list'ning Ears admir'd.
Ye learned Heads, that Sound's Progression know,
My Distance from the floating Vessel show.

Answer, The Distance of the Ship from you was 3 *English*
Miles, 148 Feet, or 2 Miles *Irish*, 2548 Feet, allowing
Sound to move 1142 Feet in a Second of Time.

Note, The Sound of a Bell, in the Receiver of an Air-
Pump, when the Air is exhausted, is hardly heard; nor a
Gun on the Top of *Pico Teneriff*; but in an unexhausted
Receiver, a small Bell may be heard many Paces off, and
the

the further the more the Air is compressed. These prove that Sound depends on the Vibrations of the sonorous Body on the Air.

But lest I tire any with Verse, I now return again to Prose.

79. There are three remarkable Places, on the *Terraqueous Globe*, to whose Inhabitants all the Stars are visible, on three certain Nights of the Year.

Answer, Under the *Æquator*; for at the first Part of the Night you see one Hemisphere, (or half of the Stars) which in twelve Hours Time entirely sets against Morning, when the other Half appears that was entirely hid the Evening before: Thus there are not only three remarkable Places, but all Places under or near the *Æquator*; the best Time is when the Nights are longest, if the Places be not directly under the *Æquator*.

80. There is a certain Place on the Earth, above whose Horizon *Saturn* is fifteen Years; and there is another of a considerable Distance from that, which hath *Jupiter* above five Years without Setting above their Horizon.

Answer, This Place is under or near the *Poles*, where *Saturn* continues without Setting near fifteen Years; as *Saturn* entered *Aries* about the Middle of *March*, 1702, and passed thro' the six following Signs, entering *Libra* 20th of *September*, 1715, which amounts to near fifteen Years; during which Time it may be supposed, that *Saturn* was seen above the Horizon of the *North-Pole*: Also the other Place (mentioned in the Paradox) of a considerable Distance, is the *South-Pole*, where *Jupiter* might have been seen from *March* 1707, till *March* 1714.

81. It may be demonstrated by the *Globe*, that the *Sun*, *Moon* and several of the Planets, do not move exactly fifteen Degrees hourly, from the *Meridian* of several Places on the *Continent* of *AMERICA*, but come later to their *Meridian*, than the preceding Day.

C

Answer,

Answer, Either it may be some floating Island; or this may arise from the diurnal Advance of the Sun, Moon and Planets in their particular Orbs, which exceed the fifteen Degrees hourly, or the three hundred and sixty Degrees of the Equinox by the said diurnal Motion of the Planets.

82. There is a certain Wall, in the City of *Dublin*, whose Situation is due *East* and *West*; yet, 'tis certain, the *Sun* will shine on the *North* Side thereof before six in the Evening, all the *Summer*, and on the *South* Side before six in the Morning.

Answer, The Wall here meant, whose Situation is due *East* and *West*, the *North* Side is perpendicular, the *Sun* having *North* Declination all the *Summer*, will shine on the *North* Side before six in the Evening; and the *South* Side of that Wall hath a reclining Plane, whose Inclination is greater than the Latitude of the Place; then may the *Sun* shine on that Plane before six in the Morning all the *Summer*.

Or thus,

The *Sun* being a great Body, and upon Motion; some of it will pass by a Wall before the Whole, and consequently send some of its Rays on the *North* Side before it be exactly six o'Clock, which on the Equinoctial Days is precisely when the *Sun's* Center is in a right Line with the Wall, which is a considerable Time after Part of it shines on the *North* Side *i. e.* so long as the *North* Semidiameter of the *Sun* is transiting that Line of due *East* and *West*.

83. There are several remarkable Places, above an hundred Miles asunder, which have no *Antaci*; and their *Periaci* are as far off them as their *Antipodes*; There are also two Places, above five hundred Miles asunder, which have no *Periaci*, and their *Antipodes* are as near them as their *Antaci*.

Answer, Those several Places an hundred Miles asunder, are all on the *Æquator*, which therefore have no *Antaci* and

and the *Periaci* are diametrically opposite, and are also, consequently *Antipodes*. The other two Places above five hundred Miles asunder, which have no *Periaci*, are the two *Poles*, who are both *Antiaci* and *Antipodes* to each other.

84. 'Tis certainly Matter of Fact, that three certain Travellers went a Journey, in which, tho' their Heads travelled full twelve Yards more than their Feet, yet they all returned alive with their Heads on.

Answer, According to the Corollary of the last Proposition of the third Book of *Whiston's Euclid*. If any one should travel over the whole Circumference of the Earth, the Way gone over by his Head would exceed that which was gone over by his Feet, by the Difference of Circumferences; or by the Circumference of a Circle, whose Semidiameter is the Man's own Stature.

Now suppose *Anson*, *Drake*, *Cavendish* or *Dampier*, each of them to be two Yards, then will the Diameter be four Yards, and the Circumference about twelve Yards.

85. Though it be generally affirmed, that the Arch of a great Circle, betwixt two Places, is their shortest Distance; yet there are two Places so situated, as that their Distance is considerably shorter than the Arch of a great Circle; yea, and there be several Places, betwixt which 'tis their longest Distance.

Answer, At the Bottom of the Ocean, some deep Cave, Valley, Mine, or some Places in the Earth, considerably below the Surface thereof; and for the latter Part, it must intend the *Antipodes*, which is the longest or greatest Distance possible.

86. There are certain Places in *North* Latitude, whose longest Artificial Day, is considerably longer, by some Hours, than the longest Artificial Day with them in the same Degree of *South* Latitude.

Answer, The *North Pole*, or near it, because the Sun spends above eight Days more in the Artificial Day, under the

the *North Pole*, betwixt *Aries* and *Libra*, than in the Artificial Day under the *South Pole*, betwixt *Libra* and *Aries*.

87. Any two Places, of a considerable Distance from each other, whose Bearing is truly known, and is not on one of the *Cardinal Points*; yet if a Ship keep continually on the same Point, on which the Port bears off, tho' they duly rectify the *Compass*, and regard both *Currents* and *Winds*, it may be plainly demonstrated by the *Globe*, that instead of hitting it, she will be further and further off, and never will hit it on that Point.

Answer, Such is the Difference between the Angle of Position and the Rumb by the *Compass*, that if the Ship steers by the *Compass*, on the same Point that the Port bears off, by the Circle of Position, it will never hit.

88. There is a certain Place in *Great-Britain*, where, when the Tide is in, one may see the Sheep feeding on a certain neighbouring Island; yet when the Tide is out, and the Water at lowest, not one can be seen, tho' they be feeding there at the same Instant.

Answer, The Place may be the Wharf of *Greenwich*, and the Island of *Dogs* over against it, and the Appearance caused by the Refraction of Sight when the Water is high. See *Paradox 18*,

89. That no Colours are real; but what we call Red, Yellow, Green or Blue, &c. only appear so to us, according as Bodies variously receive their Light; and that there are no Colours in the Dark.

Answer, Nothing is so manifest to the Sense as Colour, nothing so obscure to the Understanding; which doubts whether it has a real Existence, or whether it only appears such to us, according as Bodies variously receive the Light; for we judge of them otherwise in the Twilight, in the Sun, and in the Shadow, otherwise beholding them slopingly, directly, or thro' a colour'd Glass. Are any Colours fairer than

than those of the *Rainbow*, and yet they are no more real than those of the Cloud : The Whiteness we behold in the Milky Way ariseth only from the Light of many small Stars; Pictures are apprehended well or ill drawn according to their Situation : Nay, the visible Species are nothing else but Qualities streaming from every terminated Body, which alter the Medium, filling the same with their Images, which they diffuse even into the Organ. Now Colours are the same; being Qualities which actually change and alter their diaphanous and illuminated Body : Or the Substance of Light it self, differently reflected from those objected Bodies, as in the Case of Prisms, &c. And to explain this Paradox more fully, extend a Yard of Scarlet Cloth, in an uniform Light, then fold it, and view one half in the Sun shine, the other half in the reflected Light, and fold it in and out, like the Paper Lanthorns of a Kite, all which diligently observe, as you move it thro' the various Degrees of Light and Shade, and you will admire the vast Variety of Colours apparent thereon, none of which are more real and inherent one than the other, only a Disposition to reflect the Varieties of Reds, as lively Carnation, Sanguine, Murry (or sable Black in the dark Shade or Absence of Light) and this Disposition arises from the Cloth being ting'd in a certain Liquor, whose minute Particles are, by Reason of their Figure and Position, adapted to refract the incident Rays of Light after such Modification, as to present Red, rather than Green, Blue, &c. which requires different Degrees of Refrangibility. See Newton's *Optics*.

90. No Man can see the same Particle of an Object with both Eyes at once, nay not with the same Eye, if the Level of its visive Axis be changed.

Answer, This Paradox seems confirm'd both by Experience and Reason. 1. Because no Man can make the Vision of both his Eyes equally perfect; but beholding a Thing first with one Eye, the other being closed, shall constantly discover it to be greater in Dimensions, in the Apprehension of one Eye than of the other. So *Gassendus*, Epist. 2. Sect. 17. testifies that the Characters of his Book appeared to his right Eye, by one fifth Part, greater in Dimensions, tho' somewhat more obscure, than to his Left. 2dly, Because of all twin

Parts of the Body, one is always more perfect and vigorous than the other, which, if not the Effect of Custom, may proceed from a more liberal Afflux of Spirits to one than the other : Or the Organical Constitution may vary a little, as if one Pupil be wider, the Christalline more Convex, &c. Such like Causes necessitate a respective Disparity in the Action.

91. The same Object speculated by the same Man, at the same Distance, and in the same Degree of Light, doth always appear greater to one Eye than the other ; and that all Men see distinctly but with one Eye at once, contrary to that Axiom, that the visive Axes of both Eyes concur and unite in the Object.

Answer, Notwithstanding the Repugnancy of this Paradox to common Opinion, yet its Verity ought to be asserted ; for the Axes of the Eyes were so ordain'd by Nature, that when one is intended the other is relaxed, nor can they be both employ'd at once, tho' both at once may be relaxed, because of the Parallelism of the Motion of the Eyes, which is evident to Sense : Nor is there more Necessity to use both Eyes, than both Arms or Legs at once ; for Instance, look but at the Top of your own Nose, and you will be soon convinc'd that you cannot discern it with both Eyes at once, but the right Side with the right Eye, and the left Side with the left Eye ; for when the *Axe* of the right Eye is converted to the right Side of the Nose, the *Axe* of the Left must be converted towards the left Ear. For a further Illustration, in the Chamber set up a Staff, retreat a few Feet, and fix your Head against the Wall, then see what Pane of Glass, or Part thereof the Staff hides from the right Eye, when the Left is shut ; also, without moving the Head, shut the right Eye and open the Left, and see what Part of the Pane is then hid, which will be very different from the former, and their Distance asunder is called the Parallax of Sight ; then open both Eyes, and view if the *Axes* of both did meet and unite in the Staff, as is generally supposed, then, of Necessity, would you observe the Staff to eclipse either both Parts of the Window together, or the Middle of the Parallax ; but you shall observe it to do neither, but only one of the

the Parts, and that on which you shall fix one of your Eyes more intently than the other: Hence we may with *Gassendus*, assure the Gunners that they shall shoot as right with both Eyes open as only with one: Thus in confus'd and imperfect Vision; tho' it may be truly said, a Man doth see with both Eyes at once, but not distinct and perfect, there being several Degrees of Vision.

92. That the Matter of a Body, when rarefy'd, doth possess no more of true Place than the Matter of the same Body condensed.

Answer, When a Fleece of Wool is distended, we say 'tis made more rare, and when compress'd more dense; now the Rarefaction consists in this, that the Hairs formerly united are disunited, and the Spaces betwixt them become larger, in which no Particle of Wool is contained, and Density is quite the contrary; now tho' a Fleece of Wool expanded includes a greater Capacity therein than when compress'd, yet the single Hairs thereof take no greater Space in either Capacity; for no Hair can possess more Space than its proper Bulk requires, but the empty airy Spaces intercepted, are enlarged in the Rarefaction and diminish in the Compression: Hence 'tis true, that the Matter of a Body rarefy'd, *i. e.* the sundry indefinite Particles possess no more of true or proper Place than the Matter of the same Body condensed, though the Surface of the same Body may possess more Place, when rarefy'd than when condensed, because then it not only takes in the Particles of Space occupied by the Particles of Matter rarefy'd, but also all the enlarged Vacuities interspersed.

93. A certain Traveller, of unquestionable Integrity relates, he, in the *East-Indies*, saw Sun, Moon and Stars all at once, at Noon-Day: Yea, and in the Reign of *Tiberius*, the Sun was seen to set at Noon, when it was Full-Moon; and tho' there was Darkness above the Earth, yet was there Light under it, nay, that very Darkness became a Light, and in a few Days two real Suns, not mock ones arose in one Day, within a few Hours of each other.

Answer, This consists of several Parts, as to the First, Father *Kircher*, in his Description of the Subterraneous World, *Lib. 2.* tell us, that by the help of a Telescope we may perceive the Sun a Body of Fire unequal in its Surface, composed of several Parts of different Nature; some fluid, some solid, and that his Disk is a Sea of Fire, wherein one may perceive an eternal Agitation of the Waves of Flame, that in some Parts of it there arises a deal of Smoke: Now 'tis very probable, that a vast Quantity of Smoke might intercept and hinder the Brightness of the Sun; as in 1547, from the 4th to the 28th of *August*, the Sun appeared reddish, and not so bright as the Moon in her total Eclipse, so that then there were many Stars visible at Noon-Day, which being as bright as at other Times, plainly shew, the fixed Stars receive not their Light from the Sun, but are rather so many Suns themselves, at an indefinite Distance.

As to the latter Part of the *Paradox*, because the Reign of *Tiberius* is mentioned, probably that preternatural Darkness which happened at our Saviour's Crucifixion, which was then Full-Moon, is meant, and the Darkness began at Noon, or 6th Jewish Hour, and continued to the 9th, which miraculous Darkness also proved a Light to *Dionysius* the *Areopagite*, of whom it is reported, that beholding it, he said, *Either the World is at an End, or the God of Nature suffers*; and in a few Days, *i. e.* on the third Day early in the Morning, before Sun-rise, arose the very Sun of Righteousness, who was, and is, *The true Light that enlightens every Man that cometh into the World*; according to *John 1. 9.*

94. There are several Places on the Continent of EUROPE, where, at some certain Seasons of the Year, if a Feather and Globe of Lead, were let fall exactly together, the Feather will reach the Bottom as soon as the Lead; which Places, then, are of such a detestable Quality, that if a Sparrow, never so lively, should chance to fly over it, it would immediately fall down in a Swoon, which upon breathing on, in the Turn of an Hand, will revive and be as brisk as ever.

Answer, In any Place where the Air-Pump is, and at any Season when the Receiver is exhausted of the Air within,
such

Such strange Effects will happen; and by *breathing upon*, in a Turn of an Hand, is intended the Re-admission of the Air, whereby the Sparrow will revive again.

95. On the Continent of *ASIA*, there is a certain Country, some of whose Inhabitants, though they live not many Hours, yet they breed and bear without Food or Care, and their Generations have continued many Ages, where also the very Desert affords them vegetable Springs of Water.

Answer, *Navaretta* tells us of a Tree called the *Bejuco*, which twists about other Trees, with its End hanging downwards, and that Travellers cut the Nib off it, and presently a Spout of Water runs out from it as clear as Crystal, enough and to spare for six or eight Men. *I drank* (saith he) *to my Satisfaction of it, and found it cool and sweet, and would drink it as oft as I found it in my Way; it is a Juice and natural Water. 'Tis the common Relief of the Herdsmen on the Mountains, when they are thirsty they lay hold on the Bejuco and drink their fill.* Collect. of Voyag. Vol. 1. pag. 355. this then is a delectable vegetable Spring of Water. Also, if an Insect may be termed an Inhabitant, *Swammerdam* mentions the *Ephemeron*, which is both an unusual and special Instance of the Brevity of Life, and a wonderful Instance of the special Care and Providence of *GOD* in the Conservation of the Species of that Animal: For, 1st. As an Animal, whose Life is determined in about five or six Hours, it needs no Food. 2^d. As to its Generation, in those five Hours of its Life it performs that and other necessary Offices of Life; for in the Beginning of its Life it sheds its Coat, and that being done, and the poor little Animal thereby rendered light and agile, it spends the rest of its short Time in frisking over the Waters, and, at the same Time, the Female droppeth her Eggs on the Waters; and the Male his Sperm on them, to impregnate them, these Eggs are spread about by the Waters, and descend to the Bottom by their own Gravity, and are hatch'd by the Warmth of the Sun, into little Worms, which make themselves Cases of the Clay and feed on the same, without any need of Parental Care.

96. 'Tis as demonstrable as wonderful, that Mathematicians may draw Lines both straight and circular, which shall always approach nearer and nearer to a given Line, even unto Infinity; but either will never be join'd to it, or if join'd will never unite or meet, save in one single Point; and tho' the Angles formed at the said Point may be diminished by Arches, yet cannot so much as be bisected by any right Line whatever; and said Angles are both greater, equal and less than a right Angle.

Answer, The Corollaries of the 16th Proposition of the third Book of *Whiston's Euclid* aforesaid, will illustrate this Paradox to which I refer, when I have told my Reader that this Paradox means, not only the Angle of Contact, but the Approach of the Asymptotes to an Hyperbola, both infinitely produced unto a Distance, less than any given one, yet never concurring with it; by this Proposition, is plainly inferr'd the infinite Divisibility of Matter, Lines and Points.

97. There is a certain Island in the Continent of EUROPE, some of whose Inhabitants are of such exquisite Sight, that even with one of their Eyes, they can actually behold ten Moons real and true, all at once, above their Horizon, yea, and ten Times the Number of Stars beheld by others with both their Eyes at the same Instant, yea, such wonderful Properties have these single-sighted few, that in Things small and near, which escape the Sight of their Neighbours, they behold new Worlds of Wonder, see all the distinct Parts and Functions of those minute Animals: Nay, like Cats, they can see in the Dark, and in an Instant, and in the Dark also, draw, to the Life, and paint in lively Colours, far beyond *Michael Angelo*, or any other, in the best Light and longest Time. Lastly, such dextrous Hands have they, that in the Turn of an Hand they can command the Sun, Moon and Planets to rise and set and perform their diurnal Revolutions and their annual ones in a few Minutes, and predict their mutual Eclipses for many Years to come.

Answer:

Answer, Any Island, any where, provided there be Mathematicians furnish'd with exquisite Telescopes, which will shew the five Satellites or Moons of *Saturn*, the four Moons of *Jupiter*, and our Moon, all which are ten in Number, such will see through them ten Stars for one beheld by our Eyes not assisted with the like; nay, in the Milky-Way, where we can't behold one, they will see an innumerable Company so close and thick set, that their united faint Light causes that Whiteness, which gives it the Denomination aforesaid. The middle Part of the *Paradox* respects the Wonders of the Microscope, and the next intends the admirable and Instantaneous Painting to the Life perform'd by the *Obscura Camera* (or dark Room) of the Philosophers; and the *Last* means the noble and useful Invention of the *Orrery*, which shews, by one Turn of the Hand, the visible Revolution of the *Earth*, *Moon*, *Venus* and *Mercury*, their mutual Aspects, Eclipses, &c. for any Time past, present or to come.

The Periodical Revolutions of the Moons of Saturn and Jupiter.

	D.	H.	M.		D.	H.	M.
<i>Jupiter's</i> { First	1	18	29	<i>Saturn's</i> { First	1	21	19
Second	3	13	15	Second	2	17	40
Third	7	3	59	Third	4	12	25
Fourth	16	18	30	Fourth	15	22	41
				Fifth	79	7	48

Q^d. There is a certain Island in *EUROPE*, for which, in four or five certain Months of the Year, if the ablest Astronomers the World has, would calculate the Moon's Rising, they would not only differ in Minutes and Seconds, but whole Hours, and from which, if they take a Journey in one Part, their Shadows will disappear; in another they will circuit all Parts of the *Compass*.

Answer, This may respect the Variety of Risings of the Planets and Stars, as to one the Cosmical, the other the Achronical, the third the Heliacal, the fourth the true or apparent diurnal Rising of the Moon: Each Astronomer, tho' exactly true, respecting that particular Rising, will differ from

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from the rest, not only in Minutes and Seconds, but Hours and Days: The latter Part of the *Paradox* respects the Diversity of Shadows; under the Poles or Polar Circles the Shadows move all round about, under the *Tropics* no Shadow at all, when the Sun is in the *Zenith*; but in the *North* Temperate, our Noon Shadow is always *North*, and in the *South* Temperate, always *South*.

99. To several Parts of this *Globe*, there be certain Planets, which are so far from coming to an Opposition, that they form neither *Trine*, *Square* nor *Sextile* Aspect with the *Sun*: And there be other Places, where, if you bring a *Mariners Compass*, though never so well touched and rectified, the Needle is of no Service, because it will turn indifferently, to any Point of the *Compass*, tho' neither Iron nor Loadstone be near.

Answer, *Venus* and *Mercury*, whose Orbits are contained within the Orbit of the Earth, never form so much as a *Sextile* Aspect with the *Sun*: And in or near the two *Poles* of the Earth, the best Needle turns indifferently to any Point of the *Compass*.

100. There be several Planets or wandering *Stars*, which at certain Times, appear and disappear, whose Light decreases as they come towards the Earth, and increases as they go from the Earth; yea, so transparent are they, that the smallest *Stars* may be seen through them: Yea, and there be others so opaque, that in Conjunction with the *Sun*, they appear as Spots in his Face, and the further they go from us the bigger they appear.

Answer, The first Part respects Comets, which wander various Ways amongst the fixed Stars, and do decrease in Light as they come towards the Earth, and increase as they go from it; through whose Tails the fixed Stars of the 6th Magnitude may be seen: The other opaque Planets, which appear as Spots now and then in the *Sun's* Face, are *Venus*, *Mercury*, and the *Moon* which appears bigger in the *Horizon*

Horizon when further from us, than in the Meridian when she is near three thousand Miles nearer us, as in *Paradox 19*. The Cause of which *Phænomenon* some attribute to the Refraction, others to the Picture in the Bottom of the Eye, others to the Judgment in great Distances, says *Gravesand*, Vol. 2. N. 731. "If we look at known Objects we judge "from the apparent Magnitude and Colour which depends "upon the Bigness of the Picture in the Bottom of the Eye, "and this on the Angle under which the Object is seen."

Now 'tis well known to Astronomers, the Picture of the Sun in the Bottom of the Eye, is the same in both Cases, and that of the Moon is less when it appears near the Horizon, because she is farther off by a Semidiameter of the Earth, which bears some Proportion to her Distance from the Earth, though little with respect to the Sun's Distance from us, yet they appear greater near the Horizon by Reason of the Interposition of the Fields and Houses betwixt us and that Part of the Heavens: Also they appear nearer to us, and of a different Colour, because of the Dimness, Grossness and Density of the lower Atmosphere, the Body of the Air is twelve times greater near the Horizon than near the Zenith, thro' which the Rays of the Sun pass; this not only magnifies the Refraction, but so dims its bright Rays, that without hurting the Eyes we can look upon him Rising or Setting; but not so when on the Meridian near the Zenith; because its Rays hitting against an infinite Number of Particles in the Air, near the Horizon are reflected or absorb'd.

Howbeit, if we see the Bodies above mentioned thro' a Tube, this apparent Distance vanishes, as also the Magnitude which is deduced from it: From our Childhood upwards, and so continually, we join the Idea of Distance with the increase of apparent Magnitude, whereby the Ideas are so closely joined that they cannot be separated; not even in those Cases in which we know they lead us into Error.

Moreover, Refraction causes the horizontal Sun and Moon to appear of an oval Figure; for their inferior Limbs are more refracted and raised higher than their superior Limbs are; and therefore these two Limbs will seem nearer to each other, while the Ends of the horizontal Diameter being equally refracted keep the same Distance.

The French observed, that an Object which at Break of Day appeared in our Horizon or level Line, or a little above it,

it, a little after Sun-rise, appeared below it; and the same Appearance they found in the Evening; for the Object before Sun-set appeared below the Level, which soon after Sun-set would appear in it, insomuch that in about half an Hour's Time the Difference has been observed to be no less than three Minutes, the Cold of the Night condensing the Vapours, making them of different Density, causes the Refraction aforesaid. Nay, three Points which appear at one Time in a straight Line, have at another Time, within half an Hour, appeared out of it considerably. Hence, even the Sight itself that is the Ray of Light, passing from Point to Point thro' the Air is not a straight Line, as to its Position, by Reason of the different Refraction which is in the Medium of the Air.

101. There be many Places of the Earth, to whose Inhabitants the *Sun* and above twice seven Planets, may be all visible in one certain Night of the Year; and one of the said Planets, tho' it ever changes, yet still, to them, turns always the same Face.

Answer, The five Moons of *Saturn*, the four Moons of *Jupiter* and our Moon, which make ten Moons, besides the usual Planets *Venus* and *Mercury*, which are interior, and *Saturn*, *Jupiter* and *Mars*, which are the superior Planets, besides the Earth. Howbeit all these Moons are visible only in those Places, where are extraordinary Telescopes, and only in those Nights when they are out of the Shade of their primary Planets about which they roll. 2dly, Our Moon, tho' ever changing, as to her Phases continually increasing or decreasing in Light; yet because her periodical Revolution, about her Orbit and Axis, is performed exactly in the same Space of Time; therefore the Moon's Axis keeps its Parallelism, and still obverts the same Hemisphere or Face to the Earth, which as to its Illumination and Obscuration, is continually changing, according to its Recess from and Access to the Sun.

102. There is a certain Fire which burns at a Distance, and yet those that are several Yards nearer and between, are not so much as warm'd by it; nay, its
Heat

Heat is greater the further it is from us, and the less the nearer it is to us.

Answer, This must be the Sun which appears like a burning Ocean, whose Beams scorch and burn near the Earth, at the Foot of a Mountain ; yet on the Top of *Pico Teneriff*, which is many Yards nearer to it, the Sun's Reflection scarce reaches or warms ; where the cold Air continually changes for fresh. Moreover, the Sun's Heat, every Body knows, is greatest in *Summer*, when he is furthest from us, and least in *Winter* when he is nearest to us ; for the Degrees of Heat and Cold do not altogether depend upon our Distance from the Sun, the Difference of which Distance is but small, and bears little Proportion to the Sun's Distance from us ; but there are other powerful concurring Causes which have certain Effects. For first of all, the direct Force of the Sun's Rays, is much stronger than when they are receiv'd obliquely ; because there are much fewer Rays in the same Space, when the Rays fall obliquely than direct : Besides in *Winter* when the Sun is nearest to us, as aforesaid, his Rays or Beams pass thro' a much greater Quantity of Air, and are deeper immers'd in our Atmosphere than they are in *Summer* when the Sun is furthest off us. Again, in *Summer* we have sixteen Hours Sun-shine, and but eight Hours Night, but in *Winter* the quite contrary ; therefore no Wonder that the longer any hard Body is exposed to the Fire the hotter it still grows ; for the Action of the Sun by which all Bodies are heated, is not transient, as its Illumination is, but permanent : For this Cause, 'tis hotter under the Tropics, than the *Æquator* itself, because the Days are longer by an Hour and half there, than under the Line, from whose Zenith the Sun recedes three Degrees in eight Days Time ; but is about a Month going so far from the Zenith under the Tropics.

103. There is one certain Place of the World where the Planets, both Inferior and Superior may be beheld constantly to move forward, in the same regular and uniform Tenor ; tho' to most Places of the Earth they appear at the same Time to be stationary, Retrograde, or to move very unequally.

Answer,

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Answer, If seen from the Sun, the true Center of the World's System, the primary Planets move all regular and direct; tho' to us, out of the Center of their Orbits, they appear sometimes Direct, sometimes Retrograde, and sometimes Stationary.

104. Of all the Stars in a Star-light Night, tho' their Number seems near infinite, and *FLAMSTEAD* has given a Catalogue of Three thousand, yet it will be hard for a piercing Eye to reckon, at any Time above an Hundred; notwithstanding in a clear Winter's Night, without Moon-shine, at first view they seem to be innumerable.

Answer. This Appearance is only a Deception of our Sight; arising from their vehement and strong Twinkling, while we look upon them confusedly and without reducing them to any Order; yet that in Reality their Number is next to infinite; appears from the Discoveries the Telescope has made; for Dr. *Hook*, with only his twelve Foot Telescope, numbers seventy eight Stars in the Compass of the *Pleiades*, where only six appear to the naked Eye; and *Anton. Maria de Reita*, affirms, he has numbred, in the single Constellation of *ORION*, two thousand.

105. Notwithstanding the diurnal Motion of the Earth about its *Axis*, and the annual Motion of the same in its Orbit, yet have sundry Astronomers attributed a third Motion to the Earth, *i. e.* that whereby the Parallelism of its *Axis* is maintain'd; which others affirm is no Motion.

Answer, The Parallelism of the Earth, or that constant Position of the Earth's *Axis*, which in every Point of its Orbit, is parallel to itself in any other Point, which never changes its Direction but always looks to the same Point of the Heavens; doth necessarily follow if the Earth has no other Motion but that round the Sun, and the other round its own *Axis*. For tho' all the Diameters of the Earth will constantly change their Position by this Rotation about its

Axis,

Axis; yet the *Axis* itself will remain at Rest (like the Center in a Circle) in its former State, the Points in the *Axis* being the only Points in that Body which have no Rotation.

106. There are several Planets said to be in Conjunction with the Sun, not only when they appear in the same Degree of their Orbit with the Sun, but when they are in that Degree of their Orbit diametrically opposite to the former.

Answer, The several Planets are *Venus* and *Mercury*, who have a two-fold Conjunction with the Sun, both in the superior and inferior, or opposite Points of their Orbits; in the first they are between the Sun and us, and then sometimes (*viz.* at their Transits) appear like spots in his Disk; and in the last the Sun is between us and them.

107. There are sundry Places of the World, when coldest, much hotter than any Part of the *Torrid Zone*, and yet no burning Mountain; and other Places, when hottest, much colder than our *Frigid Zone*.

Answer, The first must be in *Venus* or *Mercury*, and the last must be in *Saturn* or *Jupiter*.

108. What Seas have their Waters fresh, and no Tide either ebbs or flows? And what Straits and Springs have their Waters salt, and the Reason why.

Answer, The *Dead Sea*, the *Euxine* and *Baltic Seas* have fresh Water and no Tide, and the Straits of *Davis*, *Hudson* and *Frabisher* are salt; because the *Baltic Sea* has many Islands at the Mouth of it, that it takes not in that Quantity of Water from the main Ocean, but receives more from the many fresh-Water Rivers which discharge themselves into it from *POLAND*, *RUSSIA* and *SWEDEN*; the like concerning the *Euxine*. And in *Burgundy* and *Lorrain* there are Springs which send forth salt Water; because they dissolve the Salt which they meet with in the Earth as they run along.

109. What

109. What is the Reason of the Cohæſion of two well poliſh'd Glaſſes or Marbles, together ſo hard that three Quarters of an Hundred Weight, faſtened to the lower, will not ſeparate it from the upper one.

Answer, Doubtleſs the Preſſure of the Atmosphere, which preſſed hard upon the obverted Planes of the Glaſs or Marble; and there being no Air between, to reſiſt the external Preſſure, there muſt neceſſarily follow the Cohæſion aforeſaid: For in an exhauſted Receiver one Pound Weight ſufficed to part two ſuch Marbles, that no leſs than eighty Pound Weight, in an open Air could ſeparate; this Experiment of the famous *BOYL*, confirms the Preſſure of the Atmosphere, and the above Solution.

110. 'Tis reported by the Duke of *Genoa*, that a Ship was found in *Switzerland* with the Bodies of forty Men in it: Alſo another Ship, in the Bottom of a Lake in *Italy*, which laſt was ſuppoſed to be ever ſince the Reign of *Tiberius*: How got they there?

Answer, That the firſt could not be from *Noah's* Time, becauſe Navigation, eſpecially upon the Ocean, was not grown to ſuch Perfection in his Time as to make Ships of that Bigneſs, and Anchors of that Perfection. 2dly, If ſuch Ships had been, it might probably happen that ſome other Men or Creatures might have eſcaped with Life, beſides thoſe in the Ark. 3dly, How could a Ship of that Bigneſs, be carried ſix hundred Feet under Ground? certainly twelve Months, much leſs forty Days Rain, could not reduce the Land to ſuch a Quagmire.

Next, A ſubterraneous Navigation ſeems a ridiculous Suppoſition; wherefore for aſſigning a Cauſe ſufficient, I conceive, there cannot be a more probable one than the Effects of Earthquakes. Suppoſe then that Part of *Switzerland* was the Bottom of the Sea, when this Veſſel was directly over this Place, and an Earthquake happened juſt underneath, which did raiſe the ſame above the Level of the Water as much as 'tis now, and cloſing the Gap, incloſed both Water, Ship and Men, which it had ſwallowed.

III. That

III. That there is another more powerful Cause of the Twilight than the Reflexion of the Earth's Atmosphere.

Answer, There is an *Æthereal Air* or Atmosphere round about the Sun, which shines after the Sun's Body is set, this Orb of the Sun's Atmosphere rising sooner and setting later than the Sun itself, shines out at Mornings and Nights in a circular Figure, it being a Segment of the Sun's Atmosphere, cut by the Horizon, and its Light is quite of another Sort than that which is made by the Reflexion of our Atmosphere, but its Duration is much shorter.

P. Nonnius to find the Length of the Twilight, watch'd the Time after Sun-set, when the Twilight in the *West* was shut in, so that no more Light appeared there, than in any other Part of the Sky near the Horizon: Then, by one of the known fixed Stars having taken the true Hour of the Night, found, by several Nights Observation, that at the Time of shutting in the Twilight, the Sun was under the Horizon eighteen Degrees; and until the Sun was deprets'd so low, the Twilight continued.

The Sun being in the *Winter Tropic* maketh the longest Twilight, and from thence, as the Days increase, the Twilight decreases until it comes to the shortest, which is in a certain Parallel between the Tropic and Equinoctial, the Declination whereof is found by this Proportion: As Radius to the Sine of the Latitude, so is the Tangent of nine Degrees to the Sine of the Declination of the said Parallel. But before the Crepusculum or Twilight comes to be shortest, there is another Parallel, in which the Crepusculum is equal to the Crepusculum of the Equinoctial, which is found by this Proportion: As Radius to the Sine of the Latitude, so is the Sine of eighteen Degrees to the Sine of the Declination of the Parallel sought.

Some

Some Curious New *PARADOXES* left unanswered, for the Entertainment and Diversion of the Ingenious ; *Note*, The four first may be solved by the Globe.

112. **S**OME Mariners sailing *N. N. W.* large Distances, for some Days, found the Sun's Meridian Altitude every Day greater than the preceding Day ; and afterwards altering their Course and sailing *S. S. W.* for several Days, found that his Meridian Altitude every Day was still greater than the Day before. *Quere*, how could that be ?

113. There were two Ships at Sea in one Parallel of Latitude, and they both at one Time observed the Sun's Meridian Altitude ; one found it 28 Degrees, the other only 12 Degrees.

114. There is a Place in the World where a Ship may sail 179 Miles due South, and yet change the Elevation of the Pole only one Degree.

115. There are several Places in the World where for a certain Time every Day, the Ecliptic and the Horizon cannot be distinguished from each other, but seem to coincide and become one Circle.

116. There is a certain Lake or Lough in the North of *Ireland*, on the deepest Part of which one might let fall 30 or 40 Pounds of Lead, and yet it would not reach the Bottom in 150 Days, altho' there were no Ice or other Obstacle in the Water, to hinder it's Descent.

117. Altho'

117. Altho' Astronomers demonstrate that from the Time of the Sun's appearing on the Meridian, to his next coming to the same Meridian, is about 24 Hours; yet the Sun hath been known to transgress that Law for several Hours.

118. There are sundry Places a considerable Distance above the *Torrid Zone*, where if a Ball of Lead or some ponderous Metal, was let go, it would not descend to the Earth, but rather ascend much farther from it.

119. Walking in the City Balon, on the 20th of *June*, I accidentally met with an old Acquaintance of mine, whom I had not seen for many Months past: He upbraided me for being so great a Stranger, and asked me where I had been, especially the Day of his Marriage, which was on the 30th of *November*; to which I replied, do you see the Sun yonder? I do, said he; then said I, how is it possible that I could be present at your Wedding when I was actually on the other Side of the Sun that Day? Nay almost as far again up in the Heavens.

120. There are certain Inhabitants in *Europe* whose Situation is such, that they cannot see above four or five Yards open Space of the Sky or Firmament; but if they move a few Steps, they will have a visible Horizon and that so open and unencumbered that they may see the Sun some Minutes before he rises (or comes to the Mathematical Horizon,) and may also view him some Minutes after he is really set: But what is most surprizing, these Inhabitants are so swift in Motion that they can run thro' a Space of above 483 *English* Miles in one Hour, nay they run with such a wonderful smooth and easy Rapidity, that it is hard for any human Eye to perceive they have any Motion at all.



PART III.

CONTAINING ANSWERS

To the Hundred *Arithmetical Problems* left
unanswered in HILL's *Arithmetick* and
ALEXANDER's *Algebra*.

1. **T**O find a Number which being multiplied by 3,
subtracting 5. from the Product, and the Re-
mainder divided by 2, if the Number sought be added
to the Quotient, that the Sum may be 40.

Answer, The Number is 17.

2. To find a Number, which being multiplied by 12,
and 48 added to the Product, as much may be produced,
as if the same Number sought were multiplied by 18.

Answer, The Number is 8.

3. If

3. If the *Sun* moves every Day one Degree, and the *Moon* 13 Degrees; and at a certain Time the *Sun* be at the Beginning of *Cancer*, and in 3 Days after, the *Moon* in the Beginning of *Aries*: The Place of their next following Conjunction is demanded.

Answer, 10 Degrees and $\frac{3}{4}$ of *Cancer*. For

$$\frac{13 \times 1 \times 90 + 13 \times 1 \times 3}{1209} = \frac{1209}{1209} \text{ or } 100\frac{3}{4} \text{ from } Aries$$

$$\frac{13 \times 1 - 1 \times 1}{12} = \frac{12}{12}$$
 60 Degrees; so will come out $10\frac{3}{4}$ of *Cancer*.

4. To find a Number, to which if 11 be added and 7 subtracted from the same Number (*viz.* the first) the Sum of the Addition may be double the Remainder.

Answer, The Number is = 25.

5. To find a Number, to which if its double (triple, quadruple, &c.) be added, the Square of the same Number may be produced.

Answer, Let b = multiple, then the Number = $b + 1$.

6. To find a Number, which if added to itself, and the Sum multiplied by the same; and the same Number still subtracted from the Product: And lastly, the Remainder divided by the same, that it may produce 13.

Answer, The Number is 7.

7. To divide the Number 16 into 2 Parts, so that the Square of the greater Part may exceed the Square of the less by 32.

Answer, The Numbers are 9 and 7.

8. To

8. To divide the Number 36 into 2 Parts, so that if 12 be added to the first, and 6 to the second, the former may be the Double of the latter.

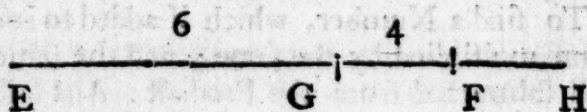
Answer, The Numbers are 24 and 12.

9. Let the Line AB (of 70 Parts) be divided any how in C (so that AC may be 42, BC 28) it is required to divide the same Line again in another Point: For Example, in D, so that the Rectangle ADC may be equal to the Square DB. Let the Segment CD be enquired (which being obtained AD, DB will be known.)



Answer, The Segment CD required is = 8.

10. Let the Line EF be divided any how in G (so that EG may be 6, GF 4) it is required to produce this right Line EF (for Example unto H) so that the Rectangle EHF may be equal to the Square GH; the Length of FH is required.



Answer, The Length of FH sought is = 8.

11. A General disposing his Army into a Square Battle, finds he has 284 Soldiers over and above; but increasing each Side with one Soldier, he wants 25 Soldiers to fill up the Square: How many Soldiers had he.

Answer, He had 24000.

Arithmetical Problems solv'd. 73

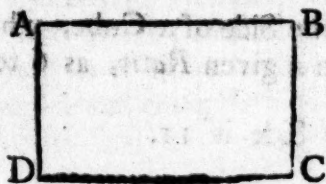
12. A certain Captain sends out $\frac{1}{3}$ of his Soldiers + 10; there remains $\frac{1}{2} + 15$. How many Soldiers had he?

Answer, He had 150.

13. There is an Army to which if you add $\frac{1}{2}$, $\frac{2}{3}$ and $\frac{1}{4}$, of itself, and take away 5000, the Sum total will be 100000. What was the Number of the Army?

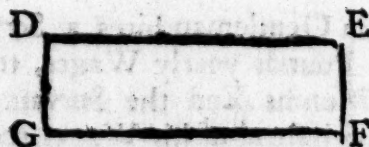
Answer, The Number was 60000.

14. In the Rectangle A B C D, the Difference of the greater Side A B, and of the lesser Side B C is 12; but the Difference of the Squares of the Sides 1680. What are the Sides of the Rectangle A B C D?



Answer, Length = 76, and Breadth = 64.

15. The Length D E of the Rectangle D E F G, is twice the Breadth E F; and the Sum of the Squares of the Length and Breadth is ten times the Sum of the two Sides D E, E F. What are the Sides of the Rectangle D E F G?



Answer, The Sides are 6 and 12.

74 *Arithmetical Problems solv'd.*

16. To find two Numbers in the Proportion of 2 to 3, whose Product, if they be multiplied by one another shall be 54.

Answer, The Numbers are 9 and 6.

17. To find two Numbers whose *Ratio* is to one another as 4 to 5; and the Sum of the Squares of both is 2624.

Answer, The Numbers are 40 and 32.

18. To find the Side of a Square, whose Area is to the Sum of the Sides in a given *Ratio*, as 45 to 12,

Answer, The Side is 15.

19. To find the Side of a Cube, whose *Superficies* is to the Solidity in a given *Ratio*, as 6 to 11.

Answer, The Side is 11.

20. A certain Man hires a Labourer, on this Condition, that for every Day he work'd he should receive 12 Pence, but for every Day he was idle he should be mulct'd 8 Pence. When 390 Days was past, neither of them were indebted to one another. How many Days did he work, and how many was he idle?

Answer, He wrought 156 Days, and was idle 234.

21. A certain Gentleman hires a Servant, and promises him 24 Pounds yearly Wages, together with a Cloak. At 8 Months End the Servant obtains Leave to go away, and instead of his Wages receives a Cloak + 13 Pounds. How much did the Cloak cost?

Answer, It cost nine Pounds.

Arithmetical Problems solv'd. 75

22. A Person being asked how old he was, answered, If I quadruple $\frac{2}{3}$ of my Years, and add $\frac{1}{2}$ of them + 50 to the Product; the Sum will be so much above 100, as the Number of my Years is now below 100.

Answer, His Age was 36 Years.

23. One being asked what Hour of the Day it was, answer'd, the Day at this Time is 16 Hours long; if now $\frac{1}{2}$ of the Hours past be added to $\frac{2}{3}$ of the Remainder, you will have the Hour desired, reckoning from Sun-Rising.

Answer, The Time from Sun-Rising is $9\frac{1}{2}$, and consequently the Time of the Day was $1\frac{1}{2}$.

24. From *Norimberg* to *Rome* are 140 Miles: A Traveller sets out at the same Time from each of the two Cities, one goes 8 Miles a Day, the other 6. In how many Days from their first setting out will they meet one another, and how many Miles does each of them go?

Answer, They'll meet in 10 Days, when the one has gone 80 and the other 60 Miles.

25. A certain Messenger goes 6 Miles every Day: 8 Days after, another follows him, and he goes 10 Miles a Day. In what Number of Days will he come up to the first.

Answer, In 12 Days.

26. A certain Messenger goes 6 Miles a Day; and after he goes 56 Miles, another follows him who goes 8 Miles a Day. In how many Days will he come up to him?

Answer, In 28 Days.

D 2

27. One

27. One bought 3 Books, whose Prices were in Proportion as 12, 5, 1: If the Price of the first be doubled, of the second tripled, of the third quadrupled; the Sum of these Products will as much exceed 10 Crowns, as the Sum of the Prices of the greatest and middle is below 5. How much did the said Books cost?

Answer, The first cost 3, the Second $1\frac{1}{2}$, and the third $\frac{1}{4}$.

28. Suppose the Number 50 were to be divided into two Parts, so that the greater Part being divided by 7, and the less multiplied by 3, the Sum of this Product and the former Quotient, may make the same Number proposed, which was 50.

Answer, The Parts are 35 and 15.

29. Let the Number 20 be divided into two Parts, so that the Square of the less Part being taken out of the Square of the greater, may leave the very Number proposed, which was 20 (or may leave the double, triple, &c. of the Number proposed.)

Answer, The Parts are 10.5 and 9.5

30. If a Man gains 30 Crowns a Week how much must he spend a Week to have 500 Crowns, together with the Expence of 4 Weeks remaining at the Year's End?

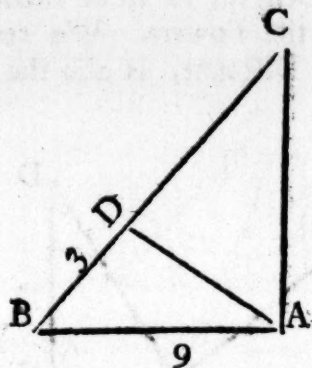
Answer, 18.92857.

31. A Labourer, after 40 Weeks in which he had been at Work, lays up 28 Crowns — the Pay of three Weeks; and finds that he had expended 36 Crowns + the Pay of eleven Weeks. What Pay did he receive a Week?

Answer,

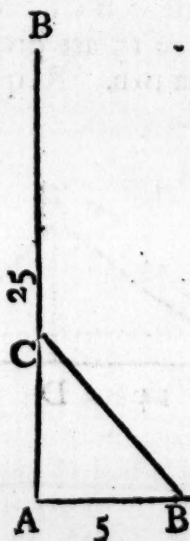
Answer, He received two Crowns per Week.

32. In the Rectangle-Triangle ABC , is given the Basis $AB = 9$ and the Difference of the other Sides, that is the Segment $BD = 3$. Required the Sides AC , BC .



Answer, The Sides are 12 and 15.

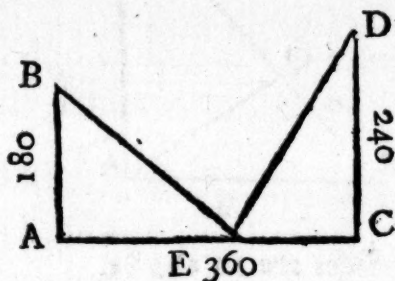
33. In the Rectangle-Triangle ABC , is given the Basis $AB = 5$, and the Sum of the other Sides $AC + BC = 25$. Required the Sides AC , BC severally.



Answer;

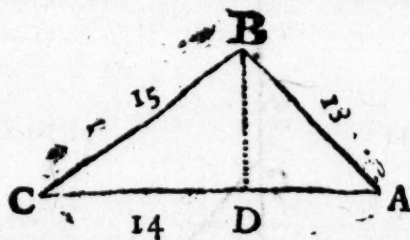
Answer, The Sides are 13 and 12.

34. Suppose two Towers, AB 180 Feet high, and CD 240, at the Distance AC 360 Feet. A Ladder is to be set upon the Line AC , at some Point suppose in E , of such a Length, as from thence it may reach the Top of both the Towers. We require the Point E in the Line of Distance, as also the Length of the Ladder EB , ED .



Answer, CE is $= 145$, AE is $= 215$, $BE = DE = 280.44$.

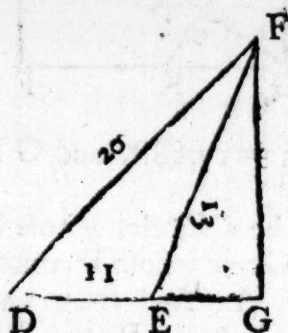
35. In the Triangle ABC , the several Sides $AB = 13$, $AC = 14$, $BC = 15$ are given; and the Perpendicular BD being drawn. Required the Segment of the Basis AD , DC .



Answer,

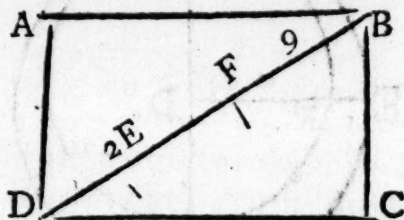
Answer, AD is $= 5$, and DC is $= 9$.

36. In the obtuseangled Triangle DEF , the several Sides are given, viz. DE 11, EF 13, DF 20; and the Perpendicular FG being let fall upon the Basis produced. Required the Prolongation of the Basis EG .



Answer, EG is $= 5$.

37. In the Rectangle $ABCD$, is given the Difference between the Length AB and the Diagonal BD , that is $DE = 2$; and likewise the Difference between the Breadth AD and the Diagonal BD , that is, $FB = 9$. Required the Sides of the Rectangle AB , AD ?

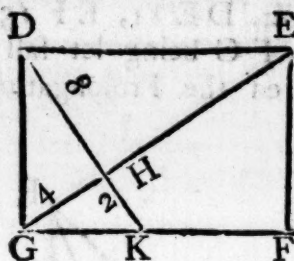


Answer, AB is $= 15$, and AD is 8 .

38. In a Rectangle $DEFG$, the right Line DK is drawn from the Angle D to the opposite Side, cutting
 $D \quad 4$
ting

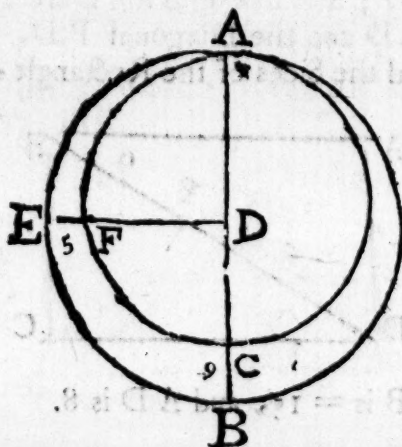
80 *Arithmetical Problems solv'd.*

ting the Diagonal EG at right Angles in H : And there is given the Segment $HK = 2$, and $HE = 16$. Required the Sides of the Rectangle?



Answer, DE is $= 17.888$, and GD is $= 8.944$.

39. Let there be a Circle, whose Diameter is AB , with another less Circle whose Diameter which is AC , touches within in A : And from the Center of the greater Circle D , draw the Radius DE at right Angles to AB , cutting the Periphery of the lesser Circle in F . Now there is given BC (the Difference of the Diameters) $= 9$, with the Segment $EF = 5$. Required the Diameters AB , AC of the said Circles?



Answer, AB is $= 50$, and AC is $= 41$.

40. Two

40. Two Companions having got a Parcel of Guineas; says A to B, if you will give me one of your Guineas I shall have as many as you will have left. Nay, replies B, if you will give me one of your Guineas, I shall have twice as many as you will have left. How many Guineas had each of them?

Answer, A had 5 and B 7.

41. A certain Person bought two Horses, with the Trappings, which cost 100 Pounds; which Trappings if laid on the first Horse A, both the Horses will be of equal Value: But if the said Trappings be laid on the other Horse, he will be double the Value of the first. How much did the said Horses cost.

Answer, This first cost 200 and the second 300.

42. A Vintner has two sorts of Wine, viz. A and B; which if mix'd in equal Parts, a Flaggon of mix'd will cost 15 Pence; but if they be mix'd in a *sesqui-alter* Proportion, as if you should take 2 Flaggons of A as often as you take 3 of B, a Flaggon will cost 14 Pence. Required the Price of each Wine singly?

Answer, A Flaggon of A is worth 20 d. and of B 10 d.

43. A Son asked his Father how old he was; his Father answered him thus, If you take away 5 from my Years, and divide the Remainder by 8, the Quotient will be $\frac{1}{3}$ of your Age: But if you add 2 to your Age, and multiply the whole by 3, and then subtract 7 from the Product, you will have the Number of the Years of my Age. What was the Age of the Father and the Son?

Answer, The Father 53 and the Son 18.

44. To find out two Numbers, to the Sum whereof if you add 6, the whole shall be double the greater; and if you subtract 2 from their Difference, the Remainder will be half of the least.

Answer. The Numbers are 14 and 8.

45. To find two Numbers, the Product whereof is 240, and the Tripple of the greater divided by less is 5.

Answer, The Numbers are 20 and 12.

46. Two Men having a Mind to purchase a House rated at 1200 Pounds; says A to B, if you give me $\frac{2}{3}$ of your Money, I can purchase the House alone; but says B to A if you will give me $\frac{1}{3}$ of yours, I shall be able to purchase the House. How much Money had each of them?

Answer, A had 800 *l.* and B 600 *l.*

47. Some young Men and Maids had a Reckoning of 37 Crowns to pay for a Treat, and this was their Conditions, that every young Man should pay 3 Crowns, and every Maid 2. Now, if there had been as many young Men as there were Maids, observing the same Conditions, the Reckoning would have come to 4 Crowns less than it did. How many young Men and Maids were there?

Answer, There were $7\frac{1}{3}$ Men, and $6\frac{2}{3}$ Maids.

48. A General who had fought a Battle, upon reviewing his Army, whose Foot was thrice the Number of his Horse, finds that before the Battle $\frac{1}{3}$ — 120 of his Foot had deserted, and of his Horse $\frac{1}{6}$ + 120, besides $\frac{1}{4}$ of his whole Army were sent into Garrisons (reckoning

reckoning the sick and wounded) and $\frac{1}{4}$ of his Army remained; the rest, who were wanting, being either slain or taken Prisoners: Now if you add 3000 to the Number of the slain, the Sum will be equal to half the Foot he had at the Beginning, What were the Numbers of each?

Answer, 30000 Foot and 10000 Horse.

49. To divide 100 twice into two Parts, so that the *major* Part of the first Division may be triple the *minor* Part of the second Division; and the *major* Part of the second may be double the *minor* Part of the first.

Answer, The Parts are 60, 40, and 80, 20.

50. To divide 30 twice into two Parts, so that the *major* Part of the first Division, with the *minor* of the second may be 33; and the Sum of the *minor* Parts subtracted from the Sum of the *major*, may leave 14 remaining.

Answer, The Parts are 20, 10, and 17, 13.

51. A Man, his Wife, and his Son's Ages make up 96 Years, so that the Husband's and Son's Years together make the Wife's + 15; but the Wife's and the Son's make the Husband's + 2. What was the Age of each?

Answer, The Husband 47 Years, the Wife 40 $\frac{1}{2}$ and the Son 8 $\frac{1}{2}$.

52. Three Merchants from three different Fairs meet together at an Inn, where they reckon up their Gains, and find them the Sum of 780 Crowns. Moreover, if you add the Gain of the first and second, and subtract the Gain of the third from the Sum, there remains

84 *Arithmetical Problems solv'd.*

mains the Gain of the first + 82 Crowns; but if you add the Gain of the second and third, and from the Sum subtra $\hat{c}$ t the Gain of the first, there remains the Gain of the third — 43 Crowns. What was the Gain of each?

Answer, The Gains were 316, 273 and 191 Pounds.

53. Three Persons, A, B, C, owe a certain Sum of Money, so that A and B together owe 210 Crowns; B and C 290, and A and C 400. What did each of them owe?

Answer, A owed 160, B 50, and C 240.

54. To find three Numbers, so that the first and half the Remainder, the second and $\frac{1}{3}$ of the Remainder, and the third and $\frac{1}{4}$ of the Remainder, may always make 34.

Answer, The Numbers are 10, 22 and 26.

55. Let a Square be divided into 9 small Squares: We are to find and dispose the Numbers through the several small Areas, so that the Sum of every three, taken either laterally or diagonally may be always 15.

Answer,

2	9	4
7	5	3
6	1	8

56. (Theorem) Let any Numbers whatsoever be given, if you subtra $\hat{c}$ t every less Numbers from that which is the next greatest: I say, that the Sum of those Differences is equal to the Difference of the greatest and least Numbers.

57. To

Arithmetical Problems solv'd. 85

57. To find a Number, which being multiplied by 6, and the Product subtracted from the Square of the Number to be found, the Remainder will be 280.

Answer, The Number is 20.

58. To find a Number which being multiplied by 8, and the Product added to the Square of the Number to be found, the Sum will be 660.

Answer, The Number is 22.

59. To divide 140 into two Parts, so that the Product of those Parts may = the Square of 56, that is 3136.

Answer, The Parts are 112 and 28.

60. Let 969 Soldiers be drawn up into an oblong Battle, so that the Difference of the greater and less Sides is 40. Required the Number of Soldiers in each Rank, in Length and Breadth.

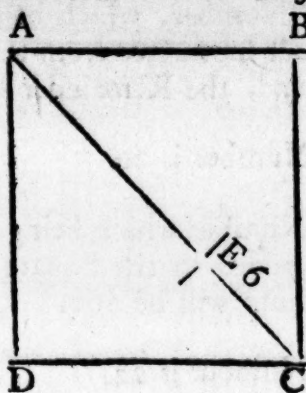
Answer, The Sides are 57 and 17.

61. Again, let 480 Soldiers be drawn up into an oblong Battle, so that the Sum of the greater and less Sides is 52. Required the Number of Soldiers of each Rank in Length and Breadth?

Answer, The Sides are 40 and 12.

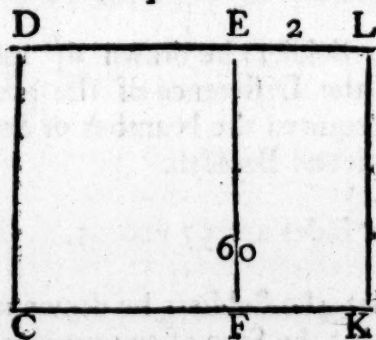
62. In the Square A B C D, is given the Difference of the Diagonal and the Side, that is $E C = 6$. Required the Side of the Square?

Answer,



Answer, The Side is 14.481.

63. The Rectangle EK is added to the Square DF (being of the same Height) whose Breadth EL is given = 2, and also the Area, of the whole compound Rectangle DK, = 60. Required the Side of the Square?



Answer, The Side 6.81.

64. A Man buys some Ells of Cloth for 70 Crowns; and finds that if he had 4 Ells more, he had then bought every Ell 2 Crowns cheaper. How many Ells did he buy?

Answer, He bought 10 Ells.

65. A Set of boon Companions dining at an Inn, the Reckoning in all came to 175 Shillings: But, before the Bill was paid off, two of them flunk away, and then the Club of those that remained came to 10 Shillings a Man more: How many were there in Company?

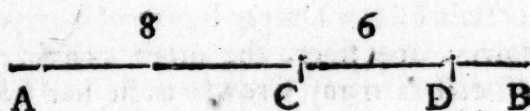
Answer, There were 7.

66. To

66. To divide the Number 21 into two Parts, so that if the greater be divided by the less; and again the less by the greater; and then the first Quotient being multiplied by 4, and the latter by 25, the Numbers produced may be equal.

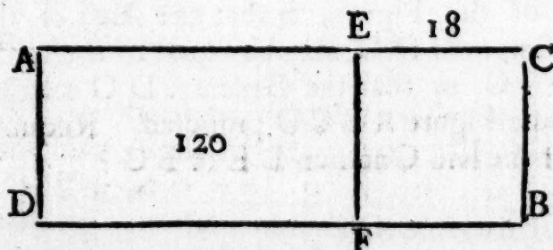
Answer, The Parts are 15 and 6.

67. Let the Line A B be divided in C, so that A C may be 8 and C D 6: We are to divide the same Line A B in D, so that the Rectangle under A D and D C may be equal to the Rectangle under A C and C B, or to the product from 8 and 6, which is 48. Required the Segment C D?



Answer, The Segment C D is = 4.

68. Let there be a Rectangular Garden, A B C D, the Length of which A B is thrice the Breadth A D; and reckoning 18 Perches from B towards A, that is B E, and reckoning E F parallel to A D, let the Area of the remaining Rectangle E D be given = 120 square Perches. What was the Length and Breadth of the said Garden?



Answer, The Length is = 30, and Breadth is = 10.

69. Let

69. Let 600 Soldiers be disposed into an oblong Battle: Which the Colonel willing to make broader, finds that if he takes away 10 Ranks from the Length, he shall augment the Breadth with two Ranks. What was the Number of his Soldiers through every Rank in Length and Breadth?

Answer, The Length is = 60, and Breadth is = 10.

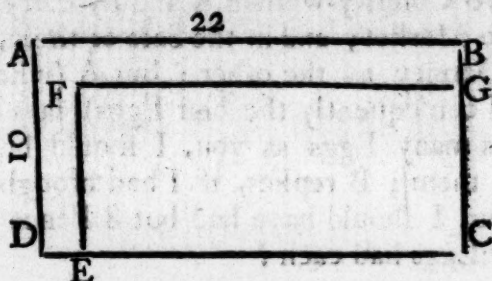
70. A Man buys a Horse, which he sells again for 56 Crowns, and gains as many Crowns in 100 as the Horse cost him. How much did he give for the Horse?

Answer, He gave 40 Crowns.

71. A certain Linen-Draper buys two Sorts of Linen for 30 Crowns, one finer, the other coarser: An Ell of the finest cost as many Crowns as he had Ells: And also 28 Ells of the coarsest at such a Price, that 8 Ells cost as many Crowns as one Ell of the finest. How many Ells of the finest Linen did he buy, and what Price did he give for them both?

Answer, 4 Ells of the finest, at 4 Crowns per Ell, the coarsest cost half a Crown per Ell.

72. In a certain rectangular Garden, the Length of which A B, is 22 Perches, and the Breadth A D is 10, the Walk D G is to be made, in a Situation parallel to the Sides of the Figure, so that the Area of the said Walk or Gnomon D G may be equal to the remaining Rectangle F C, or that the Gnomon D G may be half of the whole Figure A B C D proposed. Required the Breadth of the said Gnomon D E or B G?



Answer, The Breadth is ≈ 3.917 .

73. Of three proportional Numbers there is the middle Term given, $= 12$, and the Difference of the Extremes $= 10$. Required the Extremes?

Answer, The Extremes are 8 and 18.

74. Of three proportional Numbers there is given the Sum of the first and second, $= 10$, and the Difference of the second and third $= 24$. Required the several Numbers?

Answer, The Numbers are 2, 8, 32.

75. Of four proportional Numbers there is given the third $= 12$, also the Sum of the first and second $= 8$; besides the second Number being subtracted from its Square, the Remainder is to be the fourth. Required the said Numbers?

Answer, 3, 5, 12, 20. $3 : 5 :: 12 : 20$.

76. Of four Numbers in continued Proportion, there is given the Sum of the Means $= 24$, and likewise the Sum of the Extremes $= 36$. Required the said Numbers (supposing that the first is the least of all)?

Answer, The Numbers are $4 : 8 :: 16 : 32$.

77. Two

77. Two Country-women A and B, carry 100 Eggs together to Market; and in the Sale of them, one took as much Money as the other; but A (who had the largest and consequently the best Eggs) says to B, had I carried as many Eggs as you, I should have had 18 Pence for them; B replies, if I had brought as many Eggs as you, I should have had but 8 Pence for them. How many Eggs had each?

Answer, A had 60 and B had 40.

78. Two Country-men A and B sell their Corn at different Prices: A sells 20 Bushels; and B received for one Bushel as many Crowns as he sold Bushels: A perceives that if he had sold as many Bushels as B received Crowns, he then should have received 252 Crowns; but both together received 176 Crowns. How many Bushels did B sell, and what Price had A?

Answer, B had sold 6 Bushels, and A had 7 Crowns *per* Bushel.

79. Two Merchants sell 21 Ells of Cloth: The first sells 1 Ell for as many Crowns as is $\frac{1}{3}$ of the Number of Ells that the second had; and the second sells 1 Ell for as many Crowns as is $\frac{2}{3}$ of the Number of Ells that the first had. The Sale being over, they had taken 48 Crowns in all. How many Ells did each sell, and at what Price?

Answer, A sold 6 Ells at 3 Crowns *per* Ell, and B sold 15 Ells at 2 Crowns *per* Ell.

80. Two Merchants have a Parcel of Silk, the first 40 Ells, the second 90: The first sells for a Crown $\frac{1}{2}$ of an Ell more than the second: When the Sale was over, they had taken between them 42 Crowns. How many Ells did each of 'em sell for a Crown?

Answer,

Arithmetical Problems solv'd.

91

Answer, A sold $3\frac{1}{2}$ and B 3 Ells.

81. To find a Number, to the quadruple of which if you add 91, the Whole shall be to the Square of the Number sought, as 3 to 4.

Answer, The Number is 14.

82. To find a Number, from the double of which if you subtract 12, the Square of the Remainder — 1, will be nine times the Number sought.

Answer, The Number is 11.

83. To divide the Number 19 into two Parts, so that the Sum of the Squares of the Parts will be 193.

Answer, The Parts are 12 and 7.

84. To divide 7 into two Parts, so that the Difference of the Squares, which are made from the Triple of the less Part, and the double of the greater may be 17.

Answer. The greater Part 4 and the less 3.

85. A Man buys a Piece of Linen, and by selling it again, he gains 12 Crowns — $\frac{1}{8}$ of what he bought it for: And finds by this Means, that he had gained as much for 100 Crowns, as the Linen cost him. What Price was the Linen bought and sold at?

Answer, It cost 30 Shillings, and was sold for 39.

86. A Man buys 18 Ells of Cloth of different sorts and colour, suppose Red and Black; what he bought of each cost 40 Crowns: And he pays for every Ell of red Cloth 1 Crown more than for the black. How many Ells of each sort did he buy?

Answer,

Answer, 8 of Red and 10 of Black.

87. A Man buys 123 Pounds of Pepper, and as many of Ginger; and received for a Crown one Pound of Ginger more than of Pepper. So that the whole Price of the Pepper came to 6 Crowns more than the Price of the Ginger. How many Pounds of each did he buy for a Crown?

Answer, 4 Pounds of Pepper and 5 of Ginger.

88. A Man buys 80 Pounds of Pepper, and 36 Pounds of Saffron, so that for 8 Crowns he had 14 Pounds of Pepper more than he had of Saffron for 26 Crowns, and what he laid out amounted to 188 Crowns. How many Pounds of Pepper had he for 8 Crowns, and how many of Saffron for 26?

Answer, 20 Pounds of Pepper and 6 of Saffron.

89. A and B between them owe 174 Pound: A pays 8 Pounds a Day, and B pays the first Day 1 Pound, the second 2, the third 3, and so on. In how many Days will they clear the Debt, and how much did each of them owe?

Answer, The Debt will be paid in 12 Days, in which Time A pays 96 and B 78 Pounds.

90. A certain Man intends to travel as many Days as he has Crowns: It happens that every following Day of his Journey he had as many Crowns as he had the Day before, besides two Crowns over and above; and when he came to his Journey's End he finds he had in all 45 Crowns. How many Crowns had he at first?

Answer, He had 5 Crowns.

Arithmetical Problems solv'd. 93

91. A certain Traveller goes 9 Miles a Day, three Days after another follows him, who the first Day travels 4 Miles, the second 5, the third 6, and so on, gaining a Mile every Day. In what Time will he overtake the former ?

Answer, In 14.678881 Days.

92. Two Travellers set out at the same Time from two Cities, the one from A and the other from B, which are 70 Miles distant from one another ; one of them goes 6 Miles every Day, and the other 2 Miles the first Day, 2 and an half the second, three the third, and so on, adding half a Mile to every Day's Journey. In what Time will they meet with one another ?

Answer, In 7.30891 Days.

93. Again, Two Travellers set out at the same Time from two Cities, the one from A and the other from B, which are 120 Miles distant from one another ; the first goes 5 Miles a Day, and the other 3 Miles less than the Number of Days in which they meet. When will they meet ?

Answer, In 10 Days.

94. A Post sets out from A towards B, who travels 8 Miles a Day : After he had gone 27 Miles another sets out from B to meet him, who goes every Day $\frac{1}{18}$ of the whole Journey or Distance of the Places A and B, and meets the first Post after so many Days as is $\frac{1}{18}$ of the said Distance. Required the Distance of A and B ?

Answer, The Distance is 180 Miles.

95. Two

94 *Arithmetical Problems solv'd.*

95. Two Merchants A and B go Partners, B brings 420 Crowns, and A receives out of his Gains 52 Crowns, and the Sum of both their Shares of Stock and Gains, is 854 Crowns. How much did A bring, and how much did B receive out of the Gains ?

Answer, A brought 70, and B gain'd 312 Crowns.

96. A Son asks his Father how old he was ? his Father replies thus ; if you take 4 from my Age, the Remainder will be thrice the Numbers of your Years : But if you take 1 from your Age, half the Remainder will be the Square Root of my Age. Required the Age of the Father and Son ?

Answer, The Father 49 and the Son 15.

97. To find two Numbers, the Sum of whose Squares may be 317, and the Product, if they be multiplied by one another, 154.

Answer, The Numbers are 14 and 11.

98. To find two Numbers, the Product of which may be 108, and the Difference of the Squares 63.

Answer, The Numbers are 12 and 9.

99. Two Farmers sell two sorts of Corn : A sells 6 Bushels ; B receives in all, for his, 20 Crowns : Now, says B to A, if we add the Number of my Bushels to the Number of your Crowns, the Sum will be 28 : Says A to B, and if I add the Square of my Crowns to the Square of your Bushels, the Sum will be 424. How many Bushels did B sell, and how many Crowns did A receive ?

Answer. B sold 18 Bushels, and A received 10 Crowns.

100. To

100. To find two Numbers, the first of which $+ 2$, multiply'd into the second $- 3$, may produce 110; and on the contrary the first $- 3$, multiplied by the second $+ 2$, may produce 80.

Answer, The first is 8 and the second 14.

PARADOXICAL QUESTIONS.

N U M B E R I.

I. **O**UR Porridge-Pot, is sick, (I wot)
But what's the Matter with it
I cannot tell, nor yet reveal,
If that the Deel's not in it.

II. With Noises great it doth affright,
When first 'tis fill'd with Water,
And hung o'er Fire, with black Attire,
But what can be the Matter?

III. The Reason then, I wou'd know, when
Your Leisure doth permit.
Is't not a Frolick, or else the Cholick?
And what a sad Thing is it?

IV. Pray then be sure to send the Cure,
For if it shou'd be catching,
And other Pots do take their Lots,
What Mischief will they hatch then?

V. One Humour good, I tell you shou'd,
Our Porridge-Pot has gotten.
When boiling Diet, it is quiet,
And Pudding therein sodden.

N U M B E R II.

A Spire my Genius! Help my rhyming Muse,
 In Themes I in my native Country chuse:
 Whilst others plow the Waves and tread the Strands
 Of distant Oceans, and of foreign Lands;
 To fill the Mouth of Fame with somewhat new,
 (No matter 'tis how much of it be true)
 From Alps or Mountains, Stories strange they bring,
 Of desert Caves, or horrid Monsters sing.
 Tell how *Vesuvius*' sulph'rous Darts do fly,
 Or *Ætna*'s Smoke obscure the Azure Sky;
 Or magnify the Hazards they have run,
Scylla's and *Charybdi*'s pointed Rocks to shun.

Such Tales we take on Trust, from those who rove,
 Tho' none give Rules by which the Truth to prove.

But this by Numbers may explained be,
 By those who never did the Cavern see:

In *Derbyshire*, a Wonder of the Peak,
 Is *Elden Hole*, as Poets often speak;
 Whose Depth exactly, none could e'er descry,
 Tho' Atheist *Hobbs* his utmost Skill did try,
 Who wrote *De Mirabilibus Pecci*.

And Burlesque *Cotton* does strange Tales rehearse,
 In Rustic Words, and *Hudibrastic* Verse,
 How he this monstrous Orifice did plumb,
 But could not at the Bottom of it come,
 With sixteen hundred Yards of Rope let loose;
 And tells a Story of a Woman's Goose:
 Fabulous the one, so may the other be,
 Erroneous too, without Philosophy;
 Extension of the Rope might him deceive,
 And small Proportion which the Plumb would have
 To such a Length; and Part in Water drown'd,
 When in this vast Abyss, within the Ground.

But I the Depth have found exactly true,
 By *Gravity*, a Method something new.
 As heavy Bodies do accelerate,

In Spaces known first to our *NEWTON* Great.
Four pond'rous Stones into the Well let fall,
In measur'd Time, agreed in Numbers all;
A Pendulum sixty one Inches long,
By which the Time I measur'd (was not wrong)
Vibrated freely, whilst that each Stone fell,
Eight Times; by which the Depth I'd have you tell:
Allowing rightly for th' Approach of Sound,
That your own Works may not themselves confound.

N U M B E R III.

SINCE the Idea of Sound is conveyed to us by a Vibration communicated from the Air to the *Membrana Tympani*: I desire to know how a Man, when twenty Instruments are play'd upon at once, notwithstanding the Multiplicity of Vibrations, shall be able to distinguish, plainly, one false Note from all the rest.

N U M B E R IV.

ÆLIA, *Lelia*, *Crispis*,
Nec Vir, nec Mulier, nec Androgyna,
Nec Puella, nec Juvenis, nec Anus,
Nec Meretrix, nec Pudica,
Sed omnia:
Sublata neque Fame, nec Ferro, neque Veneno;
Sed omnibus:
Nec Cælo, nec Aquis, nec Terris;
Sed ubique jacet.
Lucius Agatho Priscus,
Nec Maritus, nec Amator, nec Necessarius,
Neque Mœrens, neque Gaudens, neque Flens,
Hanc neque Molem, nec Pyramidem, nec Sepulchrum,
Sed omnia,
Scit & nescit cui posuerit:
Hoc est Sepulchrum, intus Cadaver non habens;

E

Hoc

Hoc est Cadaver, Sepulchrum extra non habens,
Sed Cadaver idem est, & Sepulchrum sibi.

*This is a famous Inscription in Senator Volta's Country-
House, near Bologna in Italy.*

The following is a Translation of the foregoing Inscription
or Epitaph.

Æ *LIA Lelia Crispis*, who was neither Male, Female
nor Hermaphrodite, neither a Girl, a Youth, nor an
old Woman; neither a Whore, nor a modest Woman, but
was all these. She died neither by Famine, Sword nor Poi-
son; but by all three. She lies neither in the Air nor in the
Waters, nor in the Earth; but every where. *Lucius Agatho*
Priscus, who was neither her Husband, nor Gallant, nor Re-
lation; neither weeping, rejoicing, nor mourning, erected
this, which is neither a Fabric, a Pyramid, nor a Tomb,
but all three, but to whom he knows and knows not. This
is a Sepulchre not having a dead Body within it; this is a
dead Body without a Tomb; but it is a dead Body and a
Tomb to itself.

N. B. The Reader is referred to *Albby's Algebra* for So-
lutions at large of the 100 Questions, beginning at Page

Q U E S.

QUESTIONS and ÆNIGMAS left unanswer'd.

1. **O**N the 12 of *October* 1736, exactly at 11 o'Clock, a Gentleman (whose Height, from his Eye downwards, was 5 Feet 7 Inches) having flushed a Woodcock on level Ground, the Cock flew in a Line directly between his Sight and the Sun; however he fired, and the Bird fell instantly straight down, distant from the Gentleman's Foot exactly 40 Yards. *Quære* the Distance of the Bird from his Eye when he shot, in Lat. 53 d. 20 m. North ?

2. On the 10th of *June* in Lat. 52d. 00 m. N. the End of the Evening twilight being when the Sun was depressed below the Horizon 18 Degrees; also at the same Place the 14th of *December* the End of the Evening twilight happened when the Sun was 11 d. 30 m. below the Horizon; *Quære* the Height of the Atmosphere at both times ?

3. A Gentleman has 1000 *l. sterl.* which with the Interest thereof (suppose at 5 *per Cent.*) he is to spend in 20 Years, so as to spend equally each Year, and to exhaust the whole Sum and Interests at the End of 20 Years. *Quære*, How much must he spend yearly according to the above said Regulations ?

4. I demand a Rule for finding the Sum of all the Terms of this Series $\frac{N}{ab} + \frac{N}{bc} + \frac{N}{cd} + \frac{N}{de} + \text{Ec.}$ continued *ad infinitum* according to this Law, viz. 1st. The Fractions have one common Numerator. 2dly. The Denominator of every Fraction is the Product of two

E 2

corres-

corresponding Terms of the Arithmetical Series, $a, b, c, d, e, \&c.$ increasing from a , *ad infinitum*, by a common excess. I demand also a particular Answer in Numbers, supposing $N=5$; $a=1$; $b=4$; $c=7$; $d=10$; $e=1$, $\&c.$

5. A Geometrical Square whose Side is 318 Inches, it's required within the same to inscribe three equal Circles, that shall mutually touch one another, and also each to touch the Side of the Square; required the Diameter of each Circle?

6. If a flexible Chain eighteen Inches long, On *two Pins horizontal* was hung;
Whose Distance asunder exactly shall be
A Foot; it's lowest Descent then let's see,
A Theorem that's general give, for to find
The Areas of all such Curves of that Kind?

7. Ye bright Sons of Art, your Skill pray exert,
To solve these * Equations below,
(u) my Days, (a) Years, and my Months (e) declares.
Then what is my Age let me know?

$$\begin{aligned} * \quad a \times e + u &= 2706 = b \\ e \times a a + u &= 6800 = c \\ u \times a a + e &= 1500 = d \end{aligned}$$

8. If I have a Clock whose Pendulum is 42 Inches long, and its Bob 33 Pounds, I want to find at what Part thereof I must fix another Weight of $1\frac{1}{2}$ Pounds, and its Center of Oscillation, so that it may perform each Vibration in the shortest Time possible, supposing the Pendulum void of Gravity?

9. It is required to find the Length of a Pendulum, which being whirled about in an horizontal Direction shall perform each Gyration in the Space 1.5 Seconds
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QUESTIONS.

101

of Time, and that the centrifugal Force may be to Gravity as 2 to 3?

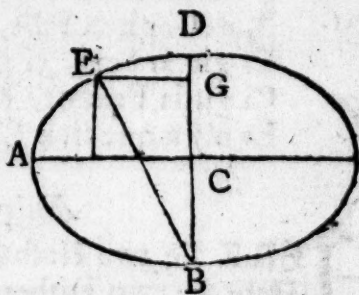
10. Three Gentlemen, *A*, *B* and *C* are determined to build a Church, towards which *A* pays 48 *l*. *B* 60 *l*. *C* 72 *l*. *B* and *C* dwell 8 Miles asunder, and they are resolved to have the Church so placed, that he who pays most shall have the Church the nearer to him in Proportion to what he pays; Quere, how far must the Church be built from each?

11. Fain wou'd I plant a Grove in Rows;
But how its Form I wou'd compose,
With three Trees in each Row,
To have as many Rows as Trees,
Now tell me Ladies (if you please),
'Tis what I want to know.

12. Required the Dimensions of a Cone and Globe, whose Solidities and whole Surface may be each to other alternately equal?

13. I Demand the greatest Number of Globes, of one Inch Diameter each, that can be placed about a central Globe of one Foot Diameter?

14. It is required to find the conjugate and transverse Axis of an Ellipsis, in which the longest Line possible drawn from the End of the Conjugate *B* to the Curve *AD*, may be equal to $BE = 64$, and that the Ordinate *EG* may cut the Semi-conjugate *CD* in *G*, that *CG* may be to *GD* as 4 to 3?



E 3

15. I

15. I demand a Rule to place an Arithmetic Series of 16 Terms, whose first is 3 and common difference 2, in the Form of what they call a Magic Square, that is, so that each Row of Terms, whether Horizontal, Vertical or Diagonal may make up one and the same Number.

Æ N I G M A S.

1. **M**arry'd I am, yet lead a single Life,
 Single I am, and yet I have a Wife.
 My Wife's a Lady, yet she want's a Waste;
 My Wife is common, yet she's not unchaste.
 My Wife is old, yet counts not twenty-three;
 We two are one, and yet we disagree.
 My Wife's no Whore, yet a Divorce I pray,
 No Court says I mayn't have one, or I may.
 My Wife is Physick, yet prescrib'd by none,
 She lives with me, and yet I lie alone,
 But I forget myself, and am too plain,
 Since Ladies have an apprehensive Brain.

Ænigma 2. Being an Inscription on a Tomb near Paris.

Ci gît le Fils, ci gît la Mere,
 Ci gît la Fille, avec le Pere,
 Ci gît la Seur, ci gît le Frere,
 Ci gît la Femme, & le Mari,
 Et n'y a que trois Corps icy.

Ænigma 3.

HERE lie two Husbands with their two Wives;
 Here lie two Fathers with their two Daughters;
 Here lie two Mothers with their two Sons;
 Here lie two Grandmothers with their two Granddaughters;

Here

Here
Here

W
Or Mo

Here lie two Daughters with their two Mothers;
Here lie two Maidens with their two Brothers;
Yet but six Corps in all lie buried here
All born legitimate, from Incest clear.

Enigma 4.

I'M a Limb of the Devil,
In the End of all, evil;
And an ancient Freeholder in Hell;
Yet can easily prove
That I'm often in Love;
A Native of *Scotland*, and also, live well,
I'm a Stranger in *Britain*,
But in *Wales* may be shit on!
A Foreman of great Reputation
To *Ladies* of Pleasure;
And a Member of Measure,
Well known in most Parts of the Nation,
My Virtue's so great,
That a Miser of late,
Without any chymical Aid, (as I'm told,)
But with me at command,
By the sleight of his Hand
Converted an old wooden GOD into Gold.
In holding an Eel,
Or in finishing Steel,
'Tis thought I'm an excellent small Tool;
Yet I'll make it appear,
From Bribes that I'm clear,
Tho' I deal in the Law, and with *Wal*——le!

Enigma 5.

WHEN the whole Universe lay self-confinn'd
And Worlds on Worlds were in one *Chaos* join'd;
E'er Nature's *Embrio* ripen'd into *Birth*,
Or Motion was imparted to the Earth;

Before the Planetary Dance begun,
 Or peopl'd Stars revolv'd about their *Sun* ;
 I Being had : — And Purity like mine
 May boast of its Original Divine ;
 And as its Birth-right claim the Compliment
 Of those, who stile me, *the most Excellent*.
 Th' Omnipotent, who sits enthron'd on high,
 In all the State of awful Majesty,
 Has so far honour'd me, that I am one
 Of those pure Beings which attend his Throne.
 Nor is my Residence to Heav'n confin'd,
 I'm present with, and useful to Mankind ;
 By whom I'm highly priz'd, since 'tis to me
 They owe (at least) their chief Felicity.
 With an incredible Celerity,
 From *Heav'n* to *Earth* I in a Trice can fly ;
 From whence returning, can again as soon
 Extend my Flight beyond the Silver *Moon* ;
 And in few Minutes lengthen out my Race
 Thro' the vast Regions of unbounded Space.
 Tho' I have constantly been felt or seen,
 My Nature ever hath mysterious been,
 Till a Philosopher of Worth and Fame
 Anatomiz'd me, and discern'd my Frame.
 A Company of fond conceited Elves
 Would fain ingross me wholly to themselves ;
 How vainly, let th' Observer judge, who sees
 To what a Height I *Flora's* Charms increase.
 Ye beauteous Fair, who do that Jewel prize,
 Which with Artill'ry furnishes your Eyes,
 Peruse the Riddle, and beyond all doubt,
 Before you have read me twice, you'll find me out.

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MATHEMATICAL MISCELLANY

PART IV.

CONTAINING

- I. Sundry Rules to form a pleasing *Ænigma*, and a proper Mathematical Problem with Examples.
- II. An Introduction to Astronomy in a Description of the *Copernican System*; the Doctrine of Eclipses and how to observe them; and an Account of the *Chaldean Saros*.
- III. How to know the Planets, and fixed Stars: and an easy Way to compute the Motions of the Planets for any Time past or to come.
- IV. Concerning the Equation of Time, and Pendulums, of Chronology and the Division of Time, Rules for finding the Vulgar Notes and moveable Feasts; with various new Tables framed for the like Purpose, and a perpetual Almanack.

Enlarged and improved by the Editors.

AND

An APPENDIX containing a plain and easy Introduction to the Art of DIALLING: Demonstrating the Principles of the Art, on which the Fundamentals are formed, for Projecting all Kinds of Plane Dials mechanically by Scale and Compass only, in several pertinent Examples, without any troublesome Calculation.

D U B L I N :

Printed, and sold by ISAAC JACKSON and Son at
the Globe in *Meath-street*, 1770.

E 5

MISCELLANY

PART IV.

SECTION I.

RULES for forming a pleasing ÆNIGMA.

AN *Enigma* is an ingenious and beautiful obscuring the plainest Things; which when discovered, strikes the Soul with Admiration; while we pleasingly wonder, to see how it was possible to lay, as it were, a Veil before the Sun: It is an artificial Representing a Subject under the shape of another, with so much Cunning, that hides a Thing while it discovers it, and persuades us it is something else than what it is really design'd for.

Seeing *Enigmas* have been of old the Diversion of Princes, and Entertainment at Feasts, and are revived among our annual Writers of Diaries, it will not be amiss, for the Information of their ingenious Assistants and Contributors, to exhibit some proper Rules for their Composition generally allowed of.

First, That they propose all their *Enigmas* on Subjects generally known.

Secondly, That they ascribe to no Subject a Property
or

or Quality incoherent to, or inconsistent with it. As for Example: In an *Enigma* upon *Snow*, it would be very absurd to say, it discolours all the Surface of the Sea, or defies the Fury of *Ætnean* Flames.

Thirdly, That they propose not particular Qualities for general. For tho' by *Synecdoche* we say *Æthiops Albus* — *quia albos habet dentes*; yet it would be very improper in an *Enigma* upon a *Blackamore*, to make him speak in general Terms — *I'm white as Down of Swans, or falling Snow*. Another Caution which may be reduced to this Rule is, That they propose not certain Numbers for uncertain.

Fourthly, That they have a regard to Time. In treating on Subjects which have been, but now are not: They ought always to speak in the *Preterimperfect Tense*, not in the *Present*. As were I to write an *Enigma* on *Noah's Ark*, 'twould be ridiculous I should say, all Creatures living are within its Womb. This would confine the Answerer's Thoughts entirely to Things *now in being*. To this Rule may also be added the Regard they ought to have to *Place*.

These are Maxims so plain and common, that it were an Absurdity, one would think, to violate any of them; and yet 'twere to be wished some *Enigmatists* in the *Diaries* would be tied down to them. Whenever they are violated, 'tis certain the Reader is imposed upon; for in solving an *Enigma*, until we can bring it to answer in every Particular, we cannot suppose we have found the Solution. If therefore the Proposer imposes a Falsity upon us, tho' never so small, 'tis still an Objection to our Answer, and we go on beating our Brains in endeavouring to apply to something, that which perhaps is not applicable to any Thing.

Example

Example I.

THE charming *Pbillis* once was wond'rous fair,
 Each Youth's Delight, her Parents only Care,
 Admir'd and lov'd by all the neighb'ring Swains,
 And own'd the loveliest Nymph that grac'd the Plains;
Orant she lov'd, of mean and low Degree,
 A Servant in her Father's Family.
 Her Parents knew how she her love had plac'd,
 Yet blam'd her not, because they saw 'twas chaste;
 One Hour to her each Morn they freely grant,
 For private Converse with her dear *Orant*.
 Unskill'd in Language he her Heart beguiles,
 With amorous Looks, and with obliging Smiles;
 All shapes he wore, yet ne'er by her was seen
 Without a beauteous Face and lovely Mien.

When thus he had her youthful Heart betray'd,
 A foul Distemper seiz'd the blooming Maid;
 Long time a burning Fever rag'd within,
 And rising Pustules spoil'd her lovely Skin.

While thus she lay, th' indulgent Mother near,
 O give me leave once more to see my dear!
 My dear *Orant*! She said, 'twill ease my Pain,
 If I can once behold *Orant* again:

Why must I now in vain with Tears implore
 That Favour which was ne'er deny'd before?

Her Mother cry'd, my Child, take no Offence,
 Your Suit is now of dang'rous Consequence;
 I can't permit you once to see your Love.
 'Till Time shall this Disorder quite remove.

At length perceiving she was left alone,
 And her Desire, as yet, fulfill'd by none,
 Up starts th' impatient Maid without Delay,
 And to *Orant's* Apartment found the Way;
 She found the Object of her Passion too,
 And cry'd, *What says he to his Phillis now?*

You're

*You're foul, you're monstrous grown (said he) therefore
Henceforth I'll see that loathsome Face no more.*

*Impatient of the Wrong, she turn'd aside,
And snatch'd a Dagger which by Chance she spy'd.
Then, half distracted, to the Scorners flew,
And at his Breast the pointed Weapon threw:
I'll make thee feel, ungrateful Wretch, she said,
The just Resentment of an injur'd Maid.*

*Pierc'd thro' and thro', he fell upon the Ground,
While she without Remorse, pursu'd the Wound:
With unrelenting Rage she trampled o'er
His Body, which with utmost Rage she tore,
And strow'd his mangled Limbs upon the Floor.*

*Ladies, no doubt this seems a monstrous Tale,
But if I should the Mystery reveal,
You'll own at last the Story may be true.
And has been acted o'er by some of you.*

*Answer, A Lady beholding her Face in a Looking-
Glass, after the Small-Pox.*

Example II.

FROM Shrubs and from Trees, and vast Caverns
below.

*And the Sweat of Mens Bodies, our Beings we owe:
But we're odd kind of Beings, and strange Pranks have
play'd,*

*Some we have delighted, and some made afraid
If two of us meet, Sir, nay, if we be three,
All Things topsy-turvey we turn presently:
But then if our Number increas'd is to four,
We set all Things to rights, Sir, as they were before
No Hands ever had we, or Colour e'er saw,
Nor ever us'd Crayon or Pencil to draw:*

Yet

Yet we paint with such delicate Colour and Shade,
And in such true Proportion our Figures are made,
That we challenge *Van Dike*, and the fam'd *Angelo*,
Such excellent Pieces, as ours are, to shew.

Answer, By the Help of *Telescope Glasses* may be represented in a *darkned Room* (as I have often myself experienced) the most lovely and charming Colours, Proportions and Distances of all outward Objects, vastly surpassing all that ever the most celebrated Painters could perform. A clear Account of this most wonderful and glorious Experiments, I shall here give you from the best Authors, and from my own Experience.

Procure a good Convex or Plano-Convex Glas; or, if you take the object Glas of a Seven-Foot Telescope, there is none hardly to be preferred before it; there being several Inconveniencies in Glasses, that draw above or under that Distance.

Make choice of a Room that hath got a *North* Window (tho' an *East* or *West* may do pretty well) and let it be well darkned, so that no Light can come in, but at the Hole where your Glas is to be placed: Then make a Hole in the Shutter of the *North* Window, about an Inch (or very little more) in Diameter, and leave open the Casement, if there be one; for there must be no Glas beyond the Hole: Then fasten the Glas with its Center, in the Center of the Hole, by some small Tacks or Nails to the Shutter, and at the Distance your Glas draws, hang up a white Sheet; (or, which is all one, move the Sheet to and fro till you find the outer Objects are represented on it very distinctly) then fasten the Sheet to the Cieling with Nails: Then will, whatever is without the Hole, and opposite to it, be represented on that Sheet, with such exquisite Exactness, as far surpasses the utmost Skill of any Painter to express. For if the Sun shines brightly on the Objects, you will have the Colour of all Things there

in

tion of Light and Shadow, as is impossible to be imitated by Art ; and I never saw any Thing that comes so near this natural Landkip: But if the Sun do not shine, the Colours will be hardly visible ; and you must by all means avoid the Sun's shining near the Hole, for then all Things will be confused.

And here you have not only the Representation of outward Objects, but their very Motion also, expressed on your white Cloth: If the Wind moves the Trees, Plants or Flowers without, you have it within on your lively Picture ; and nothing can be more pleasant, than to see how the Colours of the moving Parts will change as they do without, by their being in various Positions obverted to, or shaded from the Light. The Motion of any Birds, Flies, or other Insects, are painted also in the same Perfection ; and the exact Lineaments of any Person walking at a due Distance without the Glass, will be also expressed to the Life ; and all their Motions, Postures and Gestures, will as plainly appear on the Cloth, as they do to any one's Eye without.

And nothing is wanting to render it one of the finest Sight in the World, but that all Things are inverted, and the wrong End upwards ; to remedy which, take a common Looking Glass, of twelve or fourteen Inches square, and hold it under or near the Chin with an acute Angle to your Breast: For if you do so, and look down into it, you will see all Things upon the Sheet inverted in the Glass ; and so (in this Case) will be restored to their natural and erect Positions ; and this Reflexion also from the Glass, gives it a Glaringness that is very surprizing, and makes it look like some magical Prospect ; and the moving Images, like so many Spectrums or Phantasms. And no doubt there are many Persons, that might easily be imposed upon with such a Scene ; and would not be persuaded but that it was downright Conjurat

I have

I have (saith Mr. Harris) made use of this Experiment to convince some credulous Persons that those are abused and imposed upon, who see Faces in the Glasses of some cheating Knaves amongst us, who set up for cunning Men, and discoverers of stolen Goods, &c. and have satisfied them, that much more may be done by this and some other optical Experiments, and that without the help of the Devil too, than by any of the clumsy Methods used by these Vermin.

If the Glas be placed in a Sphere, or Globe of Wood (having an Hole as large as the Glas, bored thro' it) which like the Eye of an Animal may be turned every Way, to receive the Rays coming from all Parts of the Objects, it will be of good Advantage to the Experiment.

You may with this Glas also (as well as with a Concave one) make that little Machine called the Magical Lanthorn; by Means of which are represented on a Wall in the dark, many Phantoms and terrible Apparitions, which are taken for the Effects of Magick, by those that are ignorant of the Secret. The Theory of this Lanthorn is fully explained by *Molyneux*, in his excellent Book called *Dioptrica Nova*, Prop. 56. page 183, and the Machine at large described; to which I refer my curious Reader.

And thus is one Part of the Example explained. And this also explains two more of the former Lines in these Words.

*But we're odd kind of Beings and strange Pranks have
play'd,*

Some we have delighted and some made afraid.

By which is meant, those glorious Representations of Objects in a darkned Room, upon a white Cloth (or Paper) as I have before described; and the frightful Apparitions made by the Magick Lanthorn just now mentioned. As for the two first Lines.

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*From Shrubs and from Trees, and vast Caverns below,
And the Sweat of Mens Bodies, our Beings we owe;*

is meant the Materials with which Glass is made, which is from the Shrub called *Kali* and *Wood-Asbes*, and divers other Things, which, with Coals drawn out of the Bowels of the Earth, are melted; and is the hottest Work in the World, in Blowing and Grinding, causing the *Operators* to sweat in a plentiful Manner.

SECTION II.

*Some useful and necessary Hints for the pleasing
Composition of proper Arithmetical Questions;
by Persons of a good Mathematical Genius.*

I. THE most natural Method in answering the Questions, should be a little regarded in the Composition.

II. No Question that can be answered two Ways should be allow'd of, which will necessarily lead some from the expected Answer.

III. Nothing that is very paradoxical, much less naturally impossible, and void of Demonstration, should be put for an *Arithmetical Question*.

IV. No ambiguous or doubtful Words should be used, but such as are plain and easy to be understood.

V. We should use the same Terms of Art with the latest and best Authors; or at least our Terms and Phrases should be so plain and easy, as that none may be mistaken or deceived by them: For I think it is much better and more improving, to invent something ingenious than abstruse. Nor do I see any great Benefit or Difficulty in puzzling Mankind, and racking their Brains; nor is it necessary when there is such an
infinite

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infinite Variety in Mathematicks of pleasant and profitable Propositions. All Kind of Learning is difficult enough, especially the Mathematical, to take up the short Intervals of our Time, without being made more tedious and laborious; therefore we should make it our chief Aim to facilitate and abridge it:

Example I.

WHEN fleecy Skies had cloath'd the Ground,
 With a white Mantle all around,
 Then with a Greyhound, snowy fair,
 In Milk-white Fields we cours'd a Hare;
 Just in the Midst of a Champain,
 We set her up, away she ran:
 The Hound (I think) from her was then,
 Just thirty Leaps (or three times ten).
 Oh! it was pleasant for to see,
 How th' Hare did run so timorously,
 But yet so very swift that I,
 Did think she did not run, but fly:
 When th' Dog was almost at her Heels,
 She quickly turn'd, and down the Fields
 She ran again, with full Career,
 And 'gain she turn'd to th' Place she were;
 At ev'ry Turn she gain'd of Ground
 As many Yards as the Greyhound
 Could leap at thrice, and she did make
 Just six (if I do not mistake)
 Four times she leap'd for the Dogs three,
 But two of the Dog's Leaps agree
 With three of hers. Now pray declare,
 How many Leaps he took to catch the Hare.

Answer;

Answer.

LAST *Winter* when the Fields were cloath'd,
 And to the Milk-white Snow betroth'd,
 When the Trees were cropt by frosty Weather,
 Their Buds and Leaves lay mixt together,
Sol did in *Capricorn* appear,
 And made short stay in our Hemisphere;
 The Time, I very well remember
 Was in the Middle of *December* :
 A Knot of jovial Blades did meet,
 And that our Mirth we might complete,
 Into the snowy Fields we went,
 To course the Hare was our Intent ;
 We beat the Fields with wond'rous Care,
 At last we found a boxing Hare,
 Just in the Midst of a *Champaign*
 We set her up, away she ran,
 With nimble Foot, o'er a large Plane.
 Don't wonder I use Mr. *Walker's* Verse,
 When I this coursing Match rehearse ;
 For we had there the lame Greyhound,
 And with him cours'd the Hare around ;
 I well observ'd when we did find her.
 The Dog was thirty Leaps behind her,
 It pleas'd me so, methinks I see
 The frightened Hare run timorously :
 The Dog being almost at her Heels,
 With Motion swift about she wheels,
 With full Career away she ran
 To th' Place where she at first began ;
 Six Turns in all the Hare did make,
 Their Numbers you did not mistake ;
 Proportion due I did compare,
 Between the Leaps o'th' Dog and Hare
 For her four Leaps the Dog made three,
 The Sport was charming for to see ;

Her

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Her Three, did two of his contain,
So one in nine the Dog did gain ;
How many Leaps to catch the Hare
The Dog did take, I shall declare,
Four hundred and just thirty two
They were, and so, good Sir, adieu:

Example II.

MR. Richard Wrag made a Voyage to *Constantinople* with Mr. Barton, Queen *Elizabeth's* Ambassador : And during his stay there, upon the 16th of *July*, 1594, for his Diversion he made a Trip to the *Euxine* or *Black-Sea* ; his Relation of it is thus, The 16th, of *July* accompanied with some other of our Nation, we went by Water to the *Black-Sea*, being 16 Miles from *Constantinople* ; the Sea being all the Way thither, little broader than the *Tbames* : Both Sides of the Shore being beautified with fair and goodly Buildings : At the Mouth of this *Bosphorus* lieth a Rock some 80 Yards from the Main Land, whereupon standeth a white Marble Pillar, call'd *Pompey's Pillar*, the Shadow whereof was 23 Foot long, at 9 of the Clock in the Forenoon (which is all he says of it to our Purpose ; leaving the Height of the Pillar undetermined.) Now the Latitude of the Place being found to be 41 Deg. 8 Min. it is required to find the Height of the Pillar.

Answer, The Sun's Longitude *July* 16, Anno 1594. at 9 of the Clock in the Forenoon, is according to the *Caroline Tables*, 2 Deg. 47 Min. 31 Sec. in *Leo*. Thence,

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1. To find the Sun's Declination.

	deg. min. sec.
As Radius or Sine of _____	90 : 00 : 00
To the Sine of the Sun's Distance from the next Equinoctial Point :	57 : 12 : 29
So is the Sine of the Sun's greatest Dec.	23 : 30 : 00
To the Sine of the Sun's Declination at the Day and Hour aforesaid.	19 : 35 : 06

2. To find the Sun's Height.

As the Radius or Sine of _____	90 : 00 : 00
To the Cotangent of the Poles Height	48 : 52 : 00
So is the Sine of the Sun's Distance from the Hour of 6, viz. _____	45 : 00 : 00
To the Tangent of an Arch, viz. _____	38 : 59 : 40
Which being subtracted from the Complement of the Sun's Declination, say,	
As the Cosine of the Arch found —	51 : 00 : 20
To the Cosine of the remaining Arch of Sun's Distance from the Pole —	58 : 34 : 46
So is the Sine of the Pole's Height —	41 : 08 : 00
To the Sine of the Sun's Height at the Day and Hour aforesaid. —	46 : 14 : 32

3. To find the Height of the Pillar.

As Cosine of the Sun's Height —	43 : 45 : 28
To the Length of the Shadow 23 Feet,	
So is the Sine of Sun's Height —	46 : 14 : 32
To the Height of the Pillar 24.0196 Feet.	
The Operation of Logarithms is left to the Reader to perform at his Leisure.	

S E C.

SECTION III.

*An Introduction to Astronomy in a Description
of the Solar System.*

These are thy Works, blest Architect divine !
 This Earth and all this beauteous Offspring thine,
 Thy Breath first bid inactive Matter move,
 And straight with Life, the genial Atoms strove
 Producing Animal, and Plant, and Flow'r,
 Concurrent Proof of Wisdom, and of Pow'r :
 Thy potent Word infus'd the Solar Light,
 And spread the Curtain of refreshing Night ;
 With splendid Orbs enrich'd the Void profound,
 Rang'd the bright Worlds, and roll'd their Courses round.

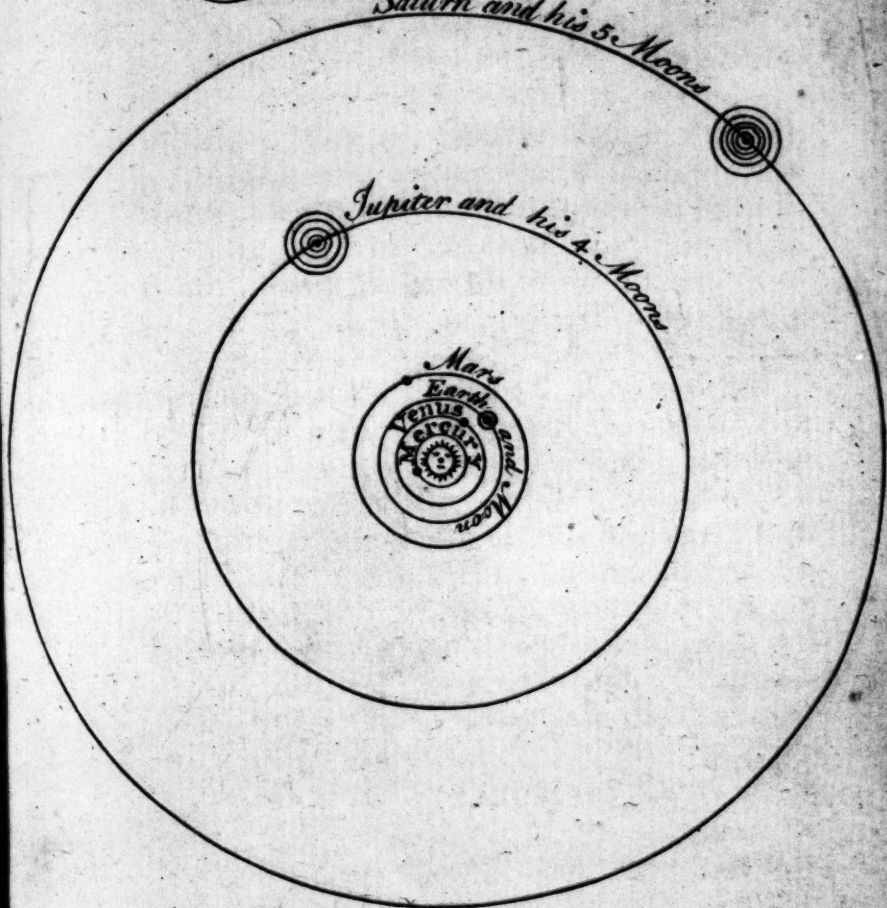
ASTRONOMY is that Science which teaches the Knowledge of the Heavenly Bodies, with respect to their Magnitudes, Distances, Motions, and Appearances thence arising.

Astronomers consider the azure Sky or Firmament as nothing more than the apparent Boundary of Sight, which must therefore seem of a spherical concave Form, in which the celestial Bodies appear placed seemingly all at an equal Distance from us ; But it is not to be imagined that they are all really placed in the same concave Surface, but that they are scattered at immense Distances from each other thro' unlimited Space : So that there may be as great a Distance between any two neighbouring Fixed Stars, as between our Sun and those which are nearest to him.

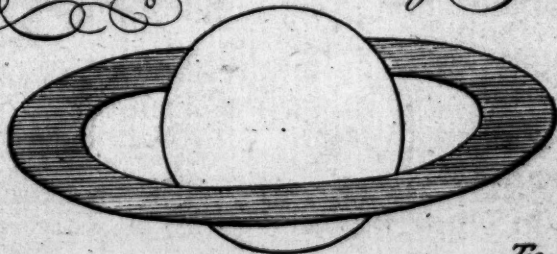
It has been found out by the Observations and Skill of Astronomers, that the Planets do not move about the Earth as a Center but about the Sun, whence our System comes to be called the *Solar System*, which was known and taught in ancient Times by the Philosopher
Pythagoras,

The Solar or Copernican System.

Saturn and his 5 Moons



Saturn and his Ring



To front page 11.

Pythagoras
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Pythagoras, from whence it is sometimes denominated the *Pythagorean System*: But this in Process of Time came to be lost, and gave Way to the prevailing false Opinions of *Ptolomy* and *Aristotle*, but was revived about the Year 1500 by *Nicholas Copernicus* a *Polish* Philosopher, from whose Name it is also called the *Copernican System*.

This System consists of the Sun, with six Primary Planets and ten Satellites or secondary Planets, also several Comets of which the Number is not yet known. The fixed Stars are to be considered as at an immense Distance, and beyond the Bounds of our System.

A Planet is a Star which changes its Place among the other celestial Bodies.—The fixed Stars are so called to distinguish them from the Planets, these do not change their Distances from each other, tho' they as well as the Planets appear to move round the Earth from East to West in about 24 Hours, but this is not caused by any Motion of theirs but by the Earth's Rotation about it's Axis from West to East. The Sun was reckoned a Planet in the antient false Systems, because of his apparently passing thro' the twelve Signs every Year, but this Motion is not real but seeming only, for by the Earth moving in her Orbit about the Sun in the Space of a Year, the same Appearance is produced, as if the Sun really moved in an Orbit round the Earth, in the same Time.

A Primary Planet, is one which only respects the Sun as a Center and no other Planet; the Primaries in our System are six, viz. *Saturn*, *Jupiter*, *Mars*, the *Earth*, *Venus* and *Mercury*; these perform their Revolutions about the Sun in elliptical Orbits, differing very little from Circles.

The Primary Planets are also distinguished by the Titles of Superior and Inferior: A Superior Planet is one whose Orbit includes the Earth's Orbit within it, and is consequently always farther from the Sun than the Earth is, such are *Saturn*, *Jupiter* and *Mars*; an Inferior

ferior Planet hath it's Orbit contained between the Earth's Orbit and the Sun, such are *Venus* and *Mercury*.

A *Secondary Planet* or *Satellite*, is one which besides its revolving round the Sun, performs smaller Revolutions about its own Primary Planet; thus, the Moon besides attending the Earth in her yearly Course round the Sun, performs thirteen Revolutions round the Earth. The Secondaries in our System are sixteen, (tho' there may possibly be some not yet discovered,) five of these revolve about *Saturn*, four about *Jupiter* and one about our *Earth*, which we call the Moon; the other Secondary Planets are also called Moons, because they vary in their Phases, and give Light to their respective Primaries, as our Moon doth to us.

All the Planets both primary and secondary are dark Bodies, and shine only by reflecting the Light they receive from the Sun.

I shall begin with the Sun, and then proceed regularly from the Planet whose Orbit is next to him, to that which is most remote and at the greatest Distance, from the Luminary of our System. (See the Plate in which the System is represented, and note the Orbits of the Satellites are much too large, as they could not be drawn small enough in Proportion to the Rest.)

The SUN is that prodigious large Body of Fire and Light, which is placed near the common Center, or rather in the lower Focus of the Orbits of all the Planets and Comets; he turns on his Axis in 25 Days 6 Hours, as is found by observing the Motion of the Spots on his Surface. (The Axis of a Planet is to be conceived an imaginary Line passing thro' it's Center, on which it turns as on a real Axis; the Poles are the Extremities of the Axis; that Pole which points towards the North Part of the Heavens is called the North Pole, and the other for a like Reason the South Pole.) The Sun is not only bigger than the Earth, but than all the sixteen Planets together: The Earth and Moon if seen from him would appear only as two very small Stars always
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near each other. He is by Computation above 800,000 times bigger than the Earth,

MERCURY is the Planet whose Orbit is next to the Sun, and contained within the Orbits of *Venus* and the Earth, he performs his Revolution round the Sun in 87 Days, 23 Hours, but the Time of his revolving on his Axis is not discovered, because there are no Spots visible on his Surface. He is never farther elongated from the Sun than 28 Degrees and an half, and very seldom rises (so long as) two Hours and an half before the Sun, or continues so long above our Horizon after Sun-set, therefore he is not often seen. He is the least of all the Primary Planets, yet greater than the Moon. His Light and Height from the Sun are almost seven times as great as ours.—When he is in Conjunction with the Sun in that Part of his Orbit, which is between the Sun and Earth, if his Latitude or Distance from the Ecliptic-Line is less than the Sun's Semidiameter, he may be seen as a dark Spot in the Sun, and this is called a Transit of *Mercury*, the last that happened was on the 9th of *November*, 1769, which was invisible here, the Sun being set to all *Europe* before it began: The next will be in 1776, 1782, 1786, 1789 and 1799.

VENUS is the next Planet, her Period is 224 Days, 17 Hours, and she revolves on her Axis once in 23 Hours; as her Orbit is contained within the Earth's Orbit, she cannot be seen very far from the Sun, and her greatest Elongation from him, does not quite amount to 48 Degrees: And because her Orbit includes *Mercury's* within it, she is seen longer before Sunrising when she is Morning-Star, and longer after Sunset when Evening-Star, than *Mercury* can be. This Planet as well as *Mercury* when viewed thro' Telescopes commonly appears (horned and varying in Shape) like the Moon. She is sometimes seen in the Sun's Disk like a black Spot, but not so frequently as *Mercury*; Astronomers had as yet but three times the Pleasure of

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seeing this curious Sight, viz. in 1639, November 24th in the Afternoon, seen only by *Horrox* and *Crabtree* in the North of *England*; in 1761, June the 6th in the Morning, and in 1769, June the 3d. in the Afternoon; the two last were seen by many Observers. In the Infancy of Astronomy these Transits were unknown, or disregarded. *Venus* is somewhat less than the Earth, but greater than either *Mars*, *Mercury* or the *Moon*; she is the brightest of all the Planets, and sometimes (when about 40 Degrees from the Sun) has been seen in the Day-time.

The EARTH is next in Order having it's Orbit between those of *Mars* and *Venus*; at the Distance of 82 Millions of Miles from the Sun (allowing his horizontal Parallax 10 Seconds,) it revolves about him in the Space of 365 Days, 6 Hours and 9 Minutes, but from any Equinox or Solstice to the same again (at a mean Rate) in 365 Days, 5 Hours, 48 Minutes, 54 Seconds; the former is the Length of the Sydereal and the latter of the Tropical Year, it revolves on it's Axis from West to East in 24 Hours, and thereby the apparent Motion of the heavenly Bodies, (the contrary Way, viz.) from East to West, is caused. It's Diameter is 7970 *Englisb* Miles, and it's Swiftness in it's Orbit is 58 Thousand Miles in an Hour.

The *Earth* like the other Planets is not exactly spherical, but an oblate Spheroid, being flatter at the Poles than at the Equator, and the Polar Diameter (or Axis), in Proportion to the Equatoreal Diameter as 229 to 230. That the Earth is of a round Form like a Globe, is known by the following Appearances, 1. The Hull of a Ship is hid from us whilst at a great Distance, by the Convexity of the Water, altho' the Tops of the Masts are visible; but if the Surface of the Water were flat, the Hull of a Ship approaching to us would be seen as soon as the Masts; or if going from us would as long continue visible, or rather longer, because the

Hull

Hull is a greater Bulk than the Masts. 2. It has been sailed round by several Navigators, not indeed in an exact Circle, but going in and out, as the Coasts happened to lie. 3. It's Shadow which is seen in Lunar Eclipses is bounded by a circular Curve, and a Body which in every position casts a circular Shade must needs be a Globe; and lastly that it is not exactly spherical but an oblate Spheroid, has been found by actual Measurement.

As for the common Objections against the Earth's Motions on it's Axis they are easily removed: One on the Earth can be no more sensible of it's moving, than a Person in the Cabin of a Ship can perceive her Motion when she turns gently round on smooth Water. Some have imagined that if the Earth turned round on it's Axis, a Ball shot up perpendicularly from a Cannon would fall down a considerable Distance from the Place whence it was fired, this Objection will appear to be of no Weight when we consider that the Gun and Ball partake of the Earth's Motion, and that the Ball being carried forward in the Air as quick as the Earth and Air turn, must fall on the same Place: A Stone let fall from the Top of a Mast if it be not obstructed, will fall on the Deck as near the Foot of the Mast if the Ship be sailing, as if she were not, for the Stone and Mast will both partake of the Ship's Motion. Some Persons object that there are some Texts of Scripture that imply the Sun moves, and that the Earth is consequently at rest, but the Scriptures were not written to instruct us in Astronomical and Mathematical Truths, they speak of these Matters according to Appearance only; and if rightly considered, there is not one of these Texts that seems to contradict the Earth's Motion more strongly, than that so very common Expression, *the Sun rises* or the *Sun sets*; and yet Sir Isaac Newton or Copernicus himself, would make Use of these Expressions, and would mean no more by them, than that it was apparently or optically so, and not caused by any Motion of the Sun, but of the Earth only.

The MOON is only a secondary Planet or Satellite of the Earth, and attends her in her annual Progress round the Sun; she is 50 times less than the Earth, and at the mean Distance of 240,000 Miles, goes round her in 27 Days, 7 Hours and 43 Minutes, in which Time she turns round her Axis, so that she always keeps (nearly) the same Face to the Earth; in the Space of 29 Days, 12 Hours, 44 Minutes (at a mean Rate) she goes thro' all her Phases or various Shapes, and this is the Length of a Day and Night in the Moon, or the Time from the Sun's appearing on any lunar Meridian to his coming on the same again.

The Moon's Phases are thus accounted for; one half of her Disk only is at once enlightened by the Sun, and that Part of her which is not enlightened is not seen by us; when she is between the Sun and the Earth, (that is in Conjunction with the Sun) her dark Side is entirely turned towards us, and she becomes invisible, at which Time it is said to be New Moon; but as she goes forward in her Orbit round the Earth, she gets a little to the East of the Sun and is seen a short time after Sun-set in the Evening, appearing of a horned Figure, a little of her enlightened half being turned towards us: Some Days after she appears half enlightened, she is then 90 Degrees from the Sun, and half of her dark and half of her enlightened Side is turned towards the Earth, and thus she appears encreasing till being in Opposition to the Sun her whole enlightened Side is presented to our View, she is then called Full Moon; afterwards her enlightened half is gradually turned away from us, and she appears decreasing in Light, (in the same regular Manner as she appeared before to encrease) until being come to another Conjunction with the Sun, she becomes invisible and it is again said to be New Moon or Change.

MARS is the next Planet in Order, his Orbit includes the Earth's Orbit within it, he turns on his Axis
in

in 24 Hours, 40 Minutes, and in 686 of our Days and 23 Hours, goes round the Sun at the Rate of 47000 *English* Miles an Hour; his Diameter is 4444 Miles, and he is near five times smaller than the Earth, he appears of a fiery red Colour like *Aldebaran*, and when in Opposition to the Sun, being then much nearer to the Earth than at other Times, he looks as large as Stars of the first Magnitude, but when pretty near his Conjunction with the Sun, he seems much decreased in Splendor and not larger than Stars of the second or third Magnitude.

JUPITER is the largest of all the Planets, his Orbit lies between the Orbits of the *Earth* and *Mars*, and at the vast Distance of 426 Millions of Miles from the Sun, he goes round him in 11 Years, 314 Days and 12 Hours; his Diameter is 81,000 Miles, and Spheres being in Proportion to each other as the Cubes of their Diameters, and the Earth's Diameter being 7970 Miles, it is found that he is 1049 times bigger than the Earth, he turns round on his Axis in 9 Hours, 56 Minutes.—About the Year 1610, *Galileo* discovered that *Jupiter* was attended by four Moons or Satellites, which are not visible without a Telescope, by Reason of their great Distance from us: For an Account of the Times in which they and *Saturn's* Satellites revolve round their Primaries, see Page 59.

SATURN is the most remote Planet in our System, his Diameter is 67,000 Miles, and he is 592 times bigger than the Earth; at the Distance of 780 Millions of Miles he goes round the Sun in 29 Years, 167 Days and 5 Hours, and travels at the Rate of 18,000 Miles an Hour: The Time in which he turns on his Axis is not discovered, because there are no Spots visible on his Surface. This Planet hath a grand Attendance of five Moons, of which the fourth (calling that the first which is next *Saturn*.) was discovered by the *Dutch* Astronomer *Hugens* in the Year 1655, and

the other four in the Year 1671, by *Cassini*, a French Astronomer: These Satellites or *Circumjovian* Planets are not visible to the naked Eye, nor can they be seen without a longer Telescope than is necessary for viewing *Jupiter's* Satellites, by Reason of their greater Distance from us. *Saturn* is encompassed with a thin broad Ring at a Distance from and no where touching him, it somewhat resembles the Horizon of an artificial Globe; when the Edge of this Ring is turned directly towards us, which happens once in fifteen Years, it appears like a Stroke or Line across the Disk of the Planet, but at other Times it is viewed obliquely and appears of an oval Form. (See the Figure of it in the Plate of the Solar System.)

COMETS commonly called Blazing Stars, are solid dark Bodies casting out transparent Tails from that Side which is turned from the Sun, the Number of them is not certainly known: They move in very eccentric Ellipses of which the lower *Foci* are in the Sun, they are only visible to us when they are in the lower Part of their Orbits near the Sun, and altho' they make Excursions vastly farther from the Sun than the Orbit of *Saturn*, yet they are always incomparably nearer to him than to any of the fixed Stars. Their Tails are supposed to be Vapours or Exhalations raised by the Sun's Heat from the Bodies of the Comets, they encrease in Length as the Comets approach towards the Sun, and again gradually diminish as they depart from him. Comets are not confined to one Part of the Heavens (as the Planets are to the Zodiac) but approach towards the Sun in all Directions.

The Ancients generally supposed the Comets to be only fiery Meteors, and had it not been for this Opinion, their Theory and Periods might have been much better known than they are at present: But now Astronomers are careful to observe all the Comets that appear, (not only those that are most perceivable and seen by

by the unskilful, but also such as are only seen by the Curious, with the Assistance of Telescopes); In Order that they may discover their Number and Periods. In the Scheme of the Solar System in *Fuller's Practical Astronomy and Use of the Globes*, there are laid down the Paths of three Comets, *viz.* that of 1680 having a Period of 575 Years; that of 1661, whose Period is thought to be almost 129 Years; and that of 1682 which was expected in 1758, but is found to return at unequal Periods; it appeared in 1759, but was not noticed in many Places.

The **FIXED STARS** are those bright, twinkling Bodies which appear in a clear Night dispersed up and down in the azure Firmament; they are called fixed, because they are observed to keep the same invariable Distance from each other, and have not any such Motions as the Planets.—They are at such an immense Distance from us, that a Telescope which magnifies 200 times shews them no other than bright Points. They shine by their own proper Light, for if they were enlightened by the Sun they would at that Distance be as invisible to us as *Jupiter's* Moons are, which appear bigger when seen thro' a good Telescope than the largest and brightest fixed Stars do. The fixed Stars that are visible to the naked Eye, are divided into six Classes according to their different apparent Magnitudes, the largest being called Stars of the first Magnitude, the next, of the second, &c.

A Number of Stars lying near together, and supposed to be circumscribed with Lines representing a Man, Beast or other Figure is called a Constellation, such are *Botes*, *Orion*, the *Lion*, *Bear*, *Crown*, &c. Twelve of these Constellations (which form a Circle or Zone of the Celestial Sphere termed the *Zodiac*) are called the twelve Signs of the *Zodiac*, or *Zodiacal Constellations*, amongst which the Planets are always found: In the Middle of this *Zodiac* or broad Zone is a Line called

the *Ecliptic*, which is described every Year by the Sun's Center in his apparent Progress thro' the twelve Signs.

The ZODIAC is divided into twelve equal Parts, each 30 Degrees in Length which are called the 12 Signs, altho' they do not exactly agree with the twelve Constellations or Starry Signs of the Zodiac, (from which they borrow their Names *Aries*, *Taurus*, &c.) which is partly by Reason of a slow apparent Motion the fixed Stars seem to have, whereby their Places in Longitude are encreased one Degree in 72 Years, so that the Constellation of the *Ram* seems still to move slowly farther from the Sign *Aries*, the *Bull* farther from the Sign *Taurus*, and so of the Rest, but the Zodiacal Constellations never did exactly agree with the 12 equal Divisions of the Zodiac or Astronomical Signs which bear the same Names, because the Constellations are of an unequal Extent, some more and some less than 30 Degrees, but the Astronomical Signs are all equal Divisions.

When there is mention made of the Sun's Place or the Place of a Planet in the Zodiac in a Degree of any Sign, it is to be understood of that Sort of Signs which are equal Divisions, and not of the Constellation of the same Name. On our celestial Globes the 12 Zodiacal Constellations or Starry Signs are distinguished by their Names written to each, *Aries*, *Taurus*, *Gemini*, &c. but the equal Divisions of the Ecliptic called Signs, are distinguished by the astronomical Characters or Marks of the 12 Signs, viz. γ , δ , π , ζ , &c. The Constellation *Aries* begins about the 28th Degree of the Sign *Aries*, the *Bull* about the 19th of *Taurus*, the *Twins* begin at the 30th or last Degree of *Gemini*, the *Crab* about the 24th of *Cancer*, the *Lion* at the 12th Degree of *Leo*, the very long Constellation of the *Maid* at the 21st of *Virgo*, the *Scales* about the 9th Degree of *Scorpio*, the *Scorpion* near the 19th of *Scorpio*, the *Half-horse-bowman* at the 28th of *Sagittarius*, the *Goat*

in the 30th Degree of *Capricorn*, the *Waterman* (stretching his Arm over the *Goat*) begins at the 9th Degree of *Aquarius* and the *Fishes* at the 15th Degree of *Pisces*.

As I designed only to write a plain and easy Introduction to Astronomy, I shall not enlarge further on this copious Subject, only just to recommend it to those that would understand Astronomy, to learn the Use of the Globes perfectly; and afterwards for a further Knowledge of this Celestial Science, they are referred to *Whiston's* astronomical Lectures, *Fuller's* Practical Astronomy and Use of the Globes, *Wells's* Gentleman's Astronomy and Dialling, *Keil's* Introduction to the true Astronomy, or other Books on this Subject.

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A Table

A Table of the Planets' Periods, Eccentricities and Distances from the Sun, &c.

Sun and Planets	Annual period round the Sun.	Time of rotation on it's Axis.	Diameter in English Miles	Mean distance from the Sun in Eng. Miles.	Eccentricity of it's Orbit in bit.	Axis inclined to Orbit. bit.	Orbit inclined to Ecliptic.	Proportion of Light & Heat.	Hourly Motion in it's Orbit. Miles.	Hourly Motion in it's Equator. Miles.
☉ Sun		25d. 6h.	763000			8° 0'		45000	None	3818
☿ Mercury	87d. 23h.	Unknown	2600	32,000,000	Unkno.	Unkno.	6°	$6\frac{1}{2}$	95000	Unkno.
♀ Venus	224d. 17h.	23h. 0m.	7906	59 000,000	413,000	75° 0'	3	$1\frac{1}{2}$	69000	1080
♂ Earth	365d. 6h.	23h. 56m.	7970	82,000,000	1,377,000	23° 28'	0	1	58000	1042
♁ Moon	365d. 6h. 27d. 7h. 43m.		2180	82,000,000	13,000	2° 10'	5 vary.	+	2290	9½
♂ Mars	686d. 23h.	24h. 40m.	4444	125,000,000	11,439,000	0	0 1	$\frac{1}{4}$	47000	556
♃ Jupiter	4332d. 12h.	9h. 56m.	81000	426,000,000	20,352,000	0	0 1	$\frac{1}{8}$	25000	25920
♄ Saturn	10759d. 7h.	Unknown	67000	78,000 000	42,735,000	Unkno.	2	$\frac{1}{8}$	18000	Unkno.

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SECTION IV.

Concerning Eclipses, and how to observe them with Safety, Pleasure and Profit.

WHEN we consider the Penetration and Contrivance necessary to lay the Foundation of Astronomy, we cannot but admire its first Inventors, such as *Thales Milefus*, who is said first to have predicted Eclipses: His Scholar *Anaximander*, who found out the Globous Figure of the Earth, the Equinoctial Points and Principles of Dialling, and made the first Sphere or Image of the Heavens: And also *Pythagoras* or his Scholars, to whom we owe the Discovery of the best System of the Planets, who were probably assisted by the *Chaldeans* and *Egyptians*, among whom (*Josephus* informs us) *Abraham* read *Lectures of Astronomy and Arithmetick*, which Sciences the *Egyptians* understood nothing of, till *Abraham*, brought 'em from *Chaldea* into *Egypt*, and from thence they passed to the *Greeks*. See *Antiq.* Book 1. Ch. 9.

But the Astronomers of our Age have attained to much greater Perfection in these Matters, especially in Eclipses of the Sun, which are much more difficult than *Lunar*. The Eclipse of the *Moon* has the same appearance to all Spectators at the same Instant: Whereas that of the Sun may appear to one Part of the Earth totally obscured, to another but in Part, on it's *North* Side, to a third on it's *South* Side, and to a fourth not at all; and all this at the same Moment of Time.

Hence it is, that the *Lunar* Eclipses equally happening at the same Instant to that Hemisphere to which the Moon is then visible, may be reduced to any other Meridian by allowing the Time, belonging to the Difference of Meridians after the Calculation is ended: But

an Eclipse of the Sun must be calculated for every different Meridian, if you will have its true Appearance, which much encreaseth its Difficulty, and among other Things made the Antients to err so much, and so often herein: Wherefore after the true Conjunction is found, change the Time by the Tables, into the Time proper to another Meridian, by allowing its Difference, to which Time and Place find the Parallaxes, &c. For the Parallax of the Moon differs in every Climate, on which the visible Eclipse of the Sun principally depends.

The Moon having only a precarious Light, is covered with real Darkness, whenever the Earth robs it of the Sun-Beams. But the Sun, on the contrary, which is Luminous, or rather Light itself, can never be really darkned by the Moon's covering it, only in Appearance to the Spectators under its Shade; it is not the Sun but the Earth that is in Darkness. Hence it may more properly be termed an Eclipse of the Earth than of the Sun; yet because of Custom, and the seeming Darkness over the Sun, I retain the common Phrase of the Eclipse of the Sun.

In general, there are more Eclipses of the Sun than of the Moon, but Eclipses of the Sun in any particular Place are much fewer than of the Moon, because the Moon's Shadow is less than the Earth's, and consequently does not involve any given Place of the Earth so oft as the Earth's Shadow does some Part of the Moon. The Moon oftener takes away the whole Sun from the Earth, than the Earth takes away the whole Sun from the Moon; the Body of the Earth being larger, receives more Transits of the Moon's Shadow, than the Moon of the Earth's Shadow; and because the Sum of the Moon's horizontal Parallax and the Semidiameters of the Sun and Moon, is never less than 85 Minutes, and the Sum of the Semidiameters of the Earth's Shadow and the Moon never more than 63, the Eclipses of the Sun may happen in a greater Latitude of the Moon than the Lunar ones;

ones; yet in respect of one and the same Place upon the Earth, the Eclipses of the Moon will be more frequent; tho' in respect of the whole Earth, Solar Eclipses may exceed in Number.

Moreover, because for many Days together, the Sun's Place is once every Year but a little distance from either Node, during which Time there happen generally two Syzygies, and consequently two Eclipses; which are the greater, the nearer any New or Full-Moon happens to the said Nodes, which Nodes are the Sections of the Moon's Orbit with the Ecliptic: In a Year there happen seldom less than two, or more than six Eclipses.

Astronomers affirm the Sun may be eclipsed more than 12 Digits, and the Moon 22 (if it had them) for a Digit is one 12th Part of their Diameter. The Sun is seldom totally eclipsed in one Place, the Moon often: And the greatest Shadow the Moon hides, is not above 200 Miles, being the greatest Difference of the Sun and Moon's Diameter, which according to the Obliquity of Horizons is greater or less. The End of the Shadow, whether of the Moon or Earth, falls short of the other Planets, and therefore they eclipse none but each other.

The Sun's Eclipse arises sooner to those that inhabit the *Western* Parts, and later to those more *Easterly*, because the Moon's proper Motion from *West* to *East* is swifter than the Sun's near 13 times; and therefore it begins on the *Western* Limb of the Sun, which Part is first restored to Light again: And if the Moon's visible Latitude be *North*, the *North* Part, but if *South*, the *South* Part of the Sun is darkned, because the Moon intercepts the Light of the Sun, on the same Side of the Ecliptic the Moon appears.

The Sun's Eclipse lasts not so long as the Moon's which sometimes exceeds four Hours; but the Sun's in any Place seldom lasts more than two Hours, because the Moon each Hour goes through half a Degree, about the

the Length of the Sun's apparent Diameter, which the Moon must be one Hour covering, and another Hour uncovering, about two Hours in all. Solar Eclipses also are very different from each other, not only because of the unequal, and uncertain Motion of the Moon, both true and apparent, the greater or lesser visible Latitude of the Moon, her Distance from the Sun, and unequal Distance of both the Luminaries from the Earth; and tho' Eclipses may happen pretty near the same Time and Place, yet they will not, for the above Reasons, be of the same Quantity and Duration; for this Rule is certain, *The heavenly Motions are incommensurable among themselves, nor have the same Phænomena in every Respect, return'd alike in any Place.*

For the newest and exactest Method of calculating Eclipses, see Dr. Gregory's *Astronomy, Book 4. Sect. 7. 8.* and Mr. Flamsteed's *Doctrine of the Sphere* in Sir Jonas Moor's *System of the Mathematics.*

Eclipses are of manifold Uses in Astronomy, Geography, Chronology and Navigation, to correct their Tables, Maps, Globes, Account of Time, and contribute very much to the Discovery of Longitude both by Sea and Land; and by the Wings of Eclipses and Parallaxes the Mind of Man flies up, and penetrates into the Celestial Regions: These are the Charms, as saith the Poet, *Which draw down the Sun and Moon on Earth*; or more truly the Knowledge of them to the inquisitive Inhabitants of the Earth; nor do I know a more evident and illustrious Proof of Astronomical Truth in Hypotheses, or Tables, than may be had from Solar and Lunar Eclipses.

There is a certain Period of the returning of Eclipses, called the *Chaldean Saros*, which is eighteen Years, eleven Days, seven Hours, forty three Minutes, when the 29th of *February* is four times included, and eighteen Years, ten Days, seven Hours, forty three Minutes, when the 29th of *February* is five times included.

This

This Period may serve very well for common Use to find and examin Eclipses by (both Solar and Lunar) but is by no means to be trusted to, for the exact Hour and Minute.

Its Use by an Example of the great Eclipse of the Sun which happened May 22d (Newstile) 1724, four Hours, forty Minutes Afternoon.

	D.	H.	M.
1724 May 22	4	40	P.M.
18	11	7	43

1742 June 2	12	23
18	10	7 43

1760 June 12	20	6
18	11	7 43

1778 June 24	3	49
18	10	7 43

1796 July 4	11	32
18	* 12	7 43

1814 July 16	19	15
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* In this last Case 12 Days are added, the 29th of February being only three times included because 1800 is not a Leap-Year in New-stile.

And from the same to move backwards.

	D.	H.	M.
1724 May 11	4	40	O.S.
18	10	7 43	

1706 April 30	20	57
18	11	7 43

1688 April 19	13	14
18	10	7 43

1670 April 9	5	31
18	11	7 43

1652 Mar. 28 21 48 At which Time happened a great Solar Eclipse from whence it was called Black-Monday.

Note, In all these Days past were great Eclipses of the Sun, either visible or invisible.—Also observe that here the Astronomical Hours are used, reckoning on from Noon to Noon 24 Hours, so March 28th 21 Hours past Noon, is in Civil Time March 29 at 9 o'Clock

o'Clock Morning, and when the Hours do not exceed twelve it is the same Hour in the Afternoon both in Astronomical and Civil Time, as *April 9th 5 Hours, 31 Minutes* (Astronomical Time) is *April 9th 31 Minutes past 5 Afternoon* in Civil Time, or the common Reckoning.

To behold a Solar Eclipse without Hurt to the Eyes.

SOME view it thro' a Pinhole in a Sheet of Paper, which defends the Eye from most of the Sun's Rays, and shews him more distinctly than with the naked Eye; others view it in a Looking-Glass, but a much more usual and better Method than the last mentioned, is to use coloured or smoked Glass, thro' which, if not too thickly smoked, the Sun may be pretty plainly seen.

Or if in a darkned Room the Sunshine be admitted only thro' a small Hole made by a Nail or Pin, the Sun's Rays coming thro' the Hole will represent the visible Part of his Disk on white Paper held at a convenient Distance, which Representation will be the plainer, the more dark the Room is, and the larger, the farther it is received from the Hole thro' which the Sun's Rays are admitted. If there be two or three Holes, there will be also as many Representations of the Eclipse; and *note*, if any Window-Glass is before the Hole it will render the Representation not so plain and distinct as otherwise, the Glass should therefore be removed, by lifting up or taking out the Sash.

Tho' I don't here intend to prescribe a Method to those Gentlemen that are furnished with Astronomical Machines, such as large Quadrants, Sextants, whereunto are affixed Telescopic Sights, yet I shall humbly offer a ready Astronomical Apparatus for others.

Prepare a Sheet of Paper, whereon is drawn a Circle,

How to observe Eclipses.

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els, about 6 Inches Diameter, divide its Circumference into 360, its Diameter by 6 Concentric Circles, into 12 equal Parts for the Digits; and another Diameter for Decimal Parts into 100, whereby the Proportion of the light and dark Parts to each other may be known; the 360 on the Limb, may serve to determine the Inclination of the Cusps of the Shade, this paste on some Wall, or Board which is better.

Then Rule a Paper, like a Surveyor's Field-Book, in 9 or 10 Columns, for the Uses following.

Observations common to the Eye: as Appearances of the Sky, Colour of the Eclipse, Stars seen, Candles lighted, or Birds flying towards their Nests,

Number of Observations.	Digits and Parts.	Decimal Parts.	Time by Pendulum.	Time by a Sun-Dial.	Sun's Altitude.	Time Corrected.
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Astronomical Observations: as Sun's Azimuth, Inclination of the Cusps, Semidiameter of the Moon, bigger or less than the Sun, whether it grows bigger or less; whether the Moon has an Atmosphere, especially to be observed, where total Darkeness happens by red Streaks of Light before and after it; also how long they are visible,

Then prepare a large Prospect with two Glasses, the Eye-Glass Concave, the Object Convex, and affix it to a Surveying Instrument, or the like, with a Ball and Socket, that it may move higher or lower, or to any Point of the Compass; and let it stand at such a Distance from the Sheet aforesaid, as just to reflect the Species of the Sun to the like Diameter already thereon drawn; which let one or two mind how the Shade commences, another observe the Sun's Altitude by a Gnomon and End of it's Shadow, whether Wall or Stake; if you have no Quadrant large enough, let some other mind the rectified Pendulum or Sun-Dial, and give Account of the mean and apparent Time and Register in their proper Columns; particularly noting the Beginning and End of total Darkeness, and of the whole, when also each Digit is eclipsed, if the Air be clear, also the Angle of Incidence, &c.

Note,

Note, The principal Things to be minded are, 1. The exact Time of the Beginning and End of the Eclipse, and of total Darknes, when and where such Eclipses happen. 2. The Duration of total Darknes. 3. The Difference of the Colour and Temper of Light. 4. The red Streaks of Light just preceding and following the total Darknes, being Indications of an Atmosphere about the Moon. But most of these last mentioned Phænomena do not happen only in a total Eclipse of the Sun.

The Method of observing Eclipses of the Moon.

Eclipses of the Moon, are observed for two principal Ends; one Astronomical, that by comparing Observations with Calculations, the Theory of the Moon's Motion may be perfected, and the Tables thereof reformed: The other Geographical, that by comparing among themselves, the Observations of the same Ecliptic Phases made in divers Places, the Difference of Meridians or Longitude of Places may be discerned.

The Knowledge of Eclipses, Quantity and Duration, the Shadows, Curvity and Inclination, &c. conduce only to the former of these Ends. The exact Time of the Beginning, Middle, and End of the Eclipses, as also in total Ones the Beginning and End of total Darknes, is useful for both of them.

But because in Observations made by the bare Eye, these Times considerably differ, from those with a Telescope, and because the Beginning of Eclipses, and the End of total Darknes, are scarce to be observed exactly even with Glasses, (none being able to distinguish between the true Shadow and *Penumbra*, unless he had seen for some Time before, the Line separating them, pass along upon the Surface of the Moon.)

Lastly, because in small Partile Eclipses, the Beginning and End in total Ones of small Consequence in the Shadow, the Beginning and End of total Darknes are unfit for nice Observation, by Reason of the slow
Change

Change of Appearances which the oblique Motion of the Shadow then causeth. For these Reasons, the following Method is necessary to accomplish the Geographical Ends in observing Lunar Eclipses, free (as far as is possible) from the forementioned Inconveniences.

First, it shall not be practicable without a Telescope. Secondly, the Observer shall always have Opportunity, before his principal Observation, to note the Distinction between the true Shadow and *Penumbra*. And Thirdly, it shall be applicable to those Seasons of the Eclipse, when there is the suddenest Alteration of the Appearances for these Intents. Let there be of the eminentest Spots dispersed over all Quarters of the Moon's Surface, a select Number generally agreed on, to be constantly made Use of to this Purpose, in all the Parts of the World; as for Example, those which Mr. *Hevelius* calleth *M. Sinai*, *M. Ætna*, *M. Porphyrites*, *M. Serorum*, *Inf. Beshica*, *Inf. Creta*, *Palus Mæotis*, *Palus Maræotis*, *Lacus Niger Major*. Let in each Eclipse, not all, but (for Instance) three of these Spots which lie nearest to the Ecliptic be exactly observed, when they are first touched by the true Shadow, and again, when they are completely entered into it, also in the Decrease of the Eclipse, when they are first fully clear from the true Shadow. For the accurate Determination of which Moments of Time, (that being in this Business of main Importance) let there be taken Altitudes of remarkable fixed Stars, not only on this Side the Line, of such as lie between the *Æquator* and Tropic of *Cancer*, but beyond the Line of such as are situated towards the other Tropic, and in all Places of such as at the Time of Observation, are about four Hours distant from the Meridian.

To observe a Solar Eclipse.

FIRST prepare a Room well darkned, into which cast the Sun's Rays through a Telescope of a competent Length as aforesaid, to the End of which fix a Paper,

Paper, pasted on a small Board, at such a Distance, that the Species of the Sun may appear thereon about five or six Inches over ; then divide the Periphery into three hundred and sixty Degrees, &c. for the better observing the Inclination of the Cusps of each Phasis, and its Diameter into Digits and Parts, by concentric Circles for the measuring the obscured Parts. Cross those Circles at right Angles, to which hang a Line and Plummert, by which you may keep the vertical and horizontal Circles in their due Situation,

I will close this *SECTION* with a Recapitulation of the Difference between an Eclipse of the Moon, and Eclipse of the Sun, which is

1. A true Obscuration or Defect of the Moon.

2. 'Tis from the Shade or Penumbra of the Earth interpos'd betwixt Moon and Sun.

3. It can only be seen by Night, or near it.

4. It only happens in the true Opposition.

5. It appears in all the nocturnal Hemisphere, every where of the same Magnitude and Duration.

6. It begins in the *Eastern* and ends in the *Western* Limb of the Moon.

and Eclipse of the Sun, which is

1. A true Obscuration, not of the Sun, but of the Earth.

2. 'Tis from the Shade or Penumbra of the Moon interposed betwixt the Sun and Earth.

3. 'Tis only seen by Day, or near it.

4. It only happens in the visible Conjunction.

5. It doth not appear in the whole diurnal Hemisphere ; and to some it is greater and longer, to some it appears less and shorter, to some it appears total or annular, to others horn'd, or none at all.

6. It begins in the *Western* Margin of the Sun, and ends in the *Eastern*.

7. If the true Latitude of the Moon be *North*; then in the Middle of the Eclipse the obscure Part of the Moon tends towards the *South*, if the Latitude be *South*, it tends towards the *North*.

8. Its greatest Duration is when the Moon is in *Perigæo* about four Hours.

9. It happens oftener than the Solar Eclipse in the same Place.

10. In the same Year there cannot be above 3 Eclipses of the Moon.

7. If the visible Latitude be *North*, the obscured Part of the Sun in the Middle of the Eclipse tends to the *North*, if *South*, towards the *South*.

8. Its greatest Duration is when the Sun is in *Apo-gæo* and Moon in *Perigæo*, about three Hours in one Place, and five Hours in different Places.

9. It happens oftner than the Lunar in divers Places.

10. In one Year there cannot happen above 5 Solar Eclipses.

In half a Year's Time may happen two central Eclipses of the Sun, or almost central, and then all that Year will be no Lunar Eclipses.

In no Year will happen less than two or more than seven Eclipses, and very seldom more than six. The total Eclipses of the Sun are more than the total Eclipses of the Moon.

SECTION V.

By what Means we may know the Stars in the Heavens.

1. **B**Y having the Picture or Representation of the Constellation by you, and knowing one or more Stars of the same Constellation, by comparing the Stars in the

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the Picture or Figure, and those in the Heaven : And considering their Situation, Distances and Magnitudes in the one, you may easily find out those in the other.

II. By the passing of some of the Planets, but especially the Moon, thro' the Signs, or by some Eminent Stars.

III. By their coming to *South*, and if withal, you have their Height given, and then by a Quadrant find their Height in the Heavens, you may, with great Certainty and Ease find them out.

IV. By their Rising and Setting, when and on what Point of the Compass ; or by their Azimuth and Altitude, using only a Quadrant and a Compass.

V. By some Instrument as the Hemisphere, Globes, or a Speaking-Tutor, who can point them out with Speed and Certainty.

To distinguish Planets from fixed Stars.

PLANETS rarely twinkle, they shift their Places from a fixed Star considerably in a Week or two : Also consult *Smith's Ephemeris*, and find what Constellations they are in : *Jupiter* and *Venus* appear larger than Stars of the first Magnitude, (and *Venus* exceeds all the other Stars in Brightness), *Saturn* equals those of the first Magnitude, *Mars* and *Mercury* seem of the second : *Saturn* of a Lead Colour, *Jupiter* of a Silver, *Mars* of a Copper, *Venus* like glistening Silver, not far from the *Sun*, and *Mercury* like Quick-silver, seldom visible, and always near the *Sun*.

SECTION VI.

A new and ready Way to compute the Motions of the Planets, for any Time past, or to come.

FOR the *Sun*. Add 1 Minute, 56 Seconds to his Place 4 Years before the given Time, and the Sum is his exact Place for the given Time ; so you may

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To compute the Planets Places. 143

may rise to any Year to come by this proportionable Addition; and likewise look back to any Number of Years; for the Time past, by deducting one Minute, 56 Seconds, for every fourth Year.

For the Moon. Look in an Ephemeris for twelve Years before, and if you would know the Place of the *Moon* for the 1st of *January*, see the Place of the *Moon* the 27th of *February*. 12 Years before, and add four Signs 1 Degree, 5 Minutes to the *Moon's* Place that 27th of *February*, and the Total is the Place of the *Moon* on the 1st of *January*, desired, so shall you be sure to have the *Moon's* Place within a few Minutes (when it differs most from the Calculation by the Tables) but for the most Part it will not differ at all; and thus proceed from Day to Day out of the old *Ephemeris*, adding still 4 S. 1 Degree, 5 Minutes, and write it against the answering Days of the new *Ephemeris* successively.

For Saturn, 1 January, 1669. I take an Ephemeris for 29 Years before, viz. 1640, then compute the Distance of *Saturn* from the *Sun* on the last of *December* in the Ephemeris for the Year 1668, and having done this, I run my Eye up and down in the Ephemeris 1640, in the Beginning of *January*, or else in the End of *December*, 1639, till I find *Saturn* at the same Distance from the *Sun* that he is the last of *December* 1668; then I consider his daily Motion from that Day to the next, and the same I allow him from the last of *December* to the first of *January* 1669, and so from Day to Day, allowing him more or less for his daily Motion, according as I find the Motion of *Saturn* either encreased, or diminished in the old Ephemeris at the same Distance from the *Sun*.

For Jupiter. Take an Ephemeris for 12 Years before, or 83 Years before, and do as for *Saturn*, considering the daily Motion of *Jupiter* in the old Ephemeris, at the same Distances he is that Day that you desire to know his Place for.

Fer

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For Mars. Take an Ephemeris for 79 Years, and do in like Manner.

For Venus. Take an Ephemeris for 8 Years, and do so.

For Mercury. Take an Ephemeris for 13 Years, and do so.

Omne bonum melius quo communius.

Questionless, much more may be done, to which I hope the Ingenious will be prompted on by this ESSAY.

If one Direction, Station and Retrogradation of a Planet be compared with another Direction, Station and Retrogradation, they will be found unequal to each other, not only with respect to the Arches in the Ecliptic, but also with respect to their Time, and this Inequality is greater in Mars than in Jupiter and Saturn; then chusing a Mean betwixt the said Inequality.

	♄	♃	♂	♀ and ♀	
The direct Pro-					
gressions of	244	284	705	542	93 Days.
Stationary	8	4	2	1½	½ Days.
Retrogradations	136	119	75	42	22 Days.
♄ is Stati-	betwixt ☐ and △ Aspects with ☉				
♃ } onary	in △ Aspect with ☉				
♂ } when	betwixt ¼ and ⅔ distant off ☉				

SECTION VII.

Of the Equation of Time; and to regulate Clocks and Watches.

HOW beneficial and necessary Pendulum-Clocks and Watches are in the Affairs of Human Life, 'tis needless to relate: But something respecting their right

right Use and Mathematical Understanding of them, may be acceptable to several.

The Clocks I here mean, are such as are made by a skilful Workman, for a Piece ill made may vary from the equal Time a Quarter of an Hour in a Month, Whereas a Piece made by a judicious Hand will not err a Minute in the same Time, if truly adjusted. As to the Exactness of these long and weighty Pendulums, we are by many curious Experiments sufficiently satisfied, that they are the most steady of all Artificial Motions, yet it will not point out by the Index continually the same Time given by the Sun on an exact Dial: But in a few Days we may be sensible of the Gain or Loss betwixt the Dial and Pendulum-Clock; now this Disagreement is not occasioned by any Defect of the Clock, but proceeds from a two-fold Inequality in the Heavenly Motions; to wit, the Eccentricity of the Orbit of the Earth, and the oblique Position of the Equator to the Ecliptic.

As to the first; we may observe, that if the yearly Orbit were indeed circular, and had the Sun in the Center; so that the Distance of the Sun from the Earth should be always the same, no Cause of this Inequality would be found in the Figure of the Earth's Orbit: But in the Elliptical Orbit, where the Quantity of the diurnal Motion is unequal, and diverse in some Days from what it is in others, the Thing must be necessarily otherwise; unequal Portions being continually added to the diurnal Revolution. As for Instance; in the *Aphelia*, the Earth by its slower Motion doth daily change its Angular Position to the Sun, less than it doth in the *Peribelia*, and consequently the Angle is less, which it doth then finish over and above its entire Revolution, to be added to that Revolution, that so the Solar Day may be compleated; for the diurnal Motion, which as to the superior Focus of the Ellipsis, is always nearly equal, is considerably unequal, with respect to the Sun near the inferior Focus; and thus an

G

Inequality

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Inequality must needs be introduced into the Natural Days.

The other Cause of the before-mentioned Inequality, is the oblique Position of the Equator to the Ecliptic. If the Axis of the Earth were always moved parallel to the Axis of the Ecliptic, and consequently the Plane of the Equator had coincided with that of the Ecliptic, there would be nothing in the Earth's Position, with respect to the Ecliptic, that might cause this Inequality. But when the diurnal and annual Motions are performed on very different Axes, then an Inequality of Days must necessarily take Place. For in this, the Sun's Longitude along the Ecliptic, and the diurnal Motion along the Equator, which we call the Sun's Right Ascension, are both taken into the Account; and unless every Arch of the Ecliptic answered to every equal Arch of the Equator, so that there were no Difference betwixt the Longitude of the Sun and his Right Ascension, which Thing cannot be; there must most certainly an Inequality of Days arise from thence, *E. G.* Let the Longitude of the Sun be five Degrees, his Right Ascension then must not by Trigonometry, exceed four Degrees, thirty five Minutes, and a Quarter, which wants twenty four Minutes and three Quarters to be equal with the Sun's Longitude: This Defect of twenty four Minutes, forty five Seconds turned into Time, comes to one Minute, forty Seconds *scilicet*, which Space, tho' in itself may seem small, yet when it is augmented for many Days successively, by an almost equal Increase, will introduce in a while an Inequality too great to be neglected.

Both the Quantity and Place of these two Causes of the Inequality here mentioned are very different in this our Age, and require to be distinctly calculated. Now the former of these Causes, to wit, the Eccentricity of the Orbit, which differs wholly from the latter, remits us to the *Apbelia* and *Peribelia* for an Equation of Time, which answers to the Quantity of that Eccentricity, and

is

is once a Year to be added to the apparent Time, and once to be subtracted from it. But the latter of these Causes which is plainly different from the former, makes an Equation of Time equal to the Difference betwixt the Sun's Longitude in the Ecliptic, and his Right Ascension in the Equator; and which being to be reckoned from the Equinoxes to the Solstices, and from the Solstices to the Equinoxes, is twice a Year Additious, and twice Ablatitious, and is almost one and an Half of the Eccentric Equation.

The whole Equation therefore of Solar Days is not to be gained from either of these Causes single or alone, but from the Combination of both, for where both the Equations are Additious, or both Ablatitious the absolute Equation of Time ariseth from the Sum of them, which is to be added to, or taken from the true Time, according to the Tenor and Name of both the Equations; and where one is additious (or to be added) and the other ablatitious (or to be taken from) thence for obtaining the Mean or even Time, the Difference of them is to be added to, or taken away from the true Time, according to the different Time of the Year, and Title of the Greater.

From this we may plainly observe, that there is a Necessity of this Equation of natural Days, seeing it is founded on true Astronomical Principles, and proved by correct Observations. I shall in the next Place apply it to Practice in regulating curious Clocks. First, we must observe that a Pendulum-Cock goes equal, that is, one twenty four Hours at any Time of the Year, is as long as another twenty four Hours at any other Time of the Year; and this is perpetual and constant, and therefore ought to differ from the apparent Time shewn by a Sun-Dial, or other Instrument, as much as is the Equation of Time in Excess or Defect. Thus, you may see by the Table, that there are only four Days in the Year on which the Equation of Days ceases, that is, the apparent and mean Time are then the same,

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viz. April the 15th, June the 16th, August the 31st, and December 23rd. If on any of these we set a well regulated Pendulum-Clock to the apparent Time shewn by the Sun, on any Day afterwards, it ought to differ from the Sun so much as is the Equation of Time by the Table; if the Equation is to be subtracted, the Pendulum ought to be so much slower than the Sun, and if the Equation is to be added, the Pendulum ought to be so much faster than the Sun.

Thus, if at any Time you desire to adjust your Clock, and bring it to measure the equal Day, you must either add or subtract the Equation of that Day to the apparent Time given by the Sun, and set the Clock to it, For Example in the Year 1769, January 1st, at Noon (the apparent Time, or true Noon being found by a Dial, or true Meridian Line) in the Table of Equation, I find four Minutes, twenty one Seconds, Sun slow, which therefore must be added, then I set my Clock four Minutes, twenty one Seconds past twelve; and observe the third Day, if it be five Minutes, seventeen Seconds faster than the Sun, then the Clock goes well; but if it goes too fast, screw down the Bob, till it gain, as in the Table (at that Time of the Year) and if it go too slow screw up the Bob, till it agree in going with the Table. Therefore your Clock must always go so much faster or slower, as the Equation in the Table, agreeing with the Time of the Year.

Those Pendulum Clocks by Experience are found, Whose Swing in a Minute makes sixty Rebounds, (As by Trial you'll find) if you measure their Lengths, Will contain just thirty nine Inches two Tenths; If so, then how long must that Pendulum be That shall make the same Number of Swings to agree With the Number of Inches its Length doth contain In the Space of a Minute, I'd know very fain?

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Of the Equation of Time, &c. 149

Answer, According to *Ricciolus*, Reciprocal Pendulum^s are to each others Length, as the Squares of their Vibrations^s in the same Time. Therefore Inches 52.06303991625108271, which is the Cube-Root of the Product of 39.2 multiplied by the Square of 60, is the true Length of a Pendulum, the Number of whole Vibrations (in one Minute of Time) and Inches shall be equal to each other.

Divide 141120 the Product aforesaid, by any given Length; the Quotient is the Square of the Number of Vibrations sought. Or,

Divide 141120 aforesaid, by the Square of the Number of Vibrations given, the Quotient will be the Length of the Pendulum sought, thereunto belonging for one Minute.

Moreover the Length of a Pendulum vibrating Seconds at *Paris* is three Feet eight Lines and an half; let it be required to find the Length of a Pendulum vibrating Seconds at the Equator.

Because the Gravity at the Poles is to the Gravity at the Equator as 692 to 689, therefore the Decrease of Gravity at the Equator is $\frac{3}{81}$ Parts of the whole Gravity; but the Decrease of Gravity at the Equator is to its Increase in any other Latitude, as the Square of Radius is to the Square of the Sine of the Latitude: as 1000000 the Square of Radius to 56,5248, the Square of the Sine of the Latitude 48 Degrees, 45 Minutes Latitude of *Paris*, so is 3 the Number which represents the Decrease of Gravity at the Equator to 1,695, the Number which represents its Increase at *Paris*, which added to 689, the Gravity at the Equator makes 690.695, the Gravity at *Paris*.

Then as 690.695 Gravity at *Paris*.

To 689 Gravity at the Equator.

So is 36.708 Length of a Pendulum at *Paris*.

To 36.616 Length of a Pendulum at the Equator:

The Difference $\frac{82}{10000}$ Parts of an Inch agreeing pretty near to the Observation of Monsieur *Richer*, who at the Island of *Caen*, whose Latitude is five Degrees, found that a Pendulum there, was $\frac{1}{10}$ of an Inch shorter than at *Paris*.

SECTION VIII.

To discover a Ship's Distance at Sea, and to know when you have cross'd the Line or the Poles, were it possible.

IN sailing near Land, if you spy two Lands, whose Distance you know, and they bear off you one Point distant afunder, when you were athwart them you are five Times their Distance from Shore, if they bear two Points, then are you 2 times and an $\frac{1}{2}$ their Distance, if 3 Points, then 1 and $\frac{1}{2}$, if 4 Points, then the same Distance, if 5 Points, but $\frac{2}{3}$ of that Distance, if 6 Points, then but $\frac{1}{2}$ their Distance.

To know when you have cross'd the Equator.

Observe if you can see *Charles's Wain* and the Guards, or Circumpolar Stars, then is the *North Pole* elevated; or if you look towards the Equator, you shall see the Stars ascend from the Left towards the Right, if in *North Latitude*; but from the Right towards the Left, if you be in *South Latitude*.

To know whether you are going to, or from the Poles.

Seeing from the *North Pole* all Places bear *South*, and near the Pole the Compass is of little Use; then get a good Clock, mark'd with 24 Hours, and an Index which shall every Noon return to 24, then when under the Pole, look and see if the Index point at 24, then that Point where the Sun is, is directly back again from the Pole.

If

If 12, then towards the Sun is right forwards.

If 6, then towards the Sun is Earth due *West*.

If 18, then towards the Sun is Earth due *East*.

Wherefore to go directly homeward, because I came out *North* and must return *South*. I lay the Fly of the Compass steady before me, and the *South* Point right with the Ship's Head or Stem, then if the Clock point 24 Hours, then I steer the Ship directly upon the Sun.

But if the Clock point	{	3	Then he that doth steer, must keep the Sun	{	South West.
		6			West.
		9			North-West.
		12			North.
		15			North-East.
		18			East.
21	South East.				

But if you would go directly forward, then lay the *North* Point right with the Ship's Head, and when the Clock doth point 12, steer right upon the Sun.

SECTION IX.

Of Time and the Division thereof.

A Year is sometimes taken for the Time of the Revolution of a Planet through the Zodiac, in which a Month is sometimes called a Year.

Another different Year is the entire Revolution (apparently) of the fixed Stars, through the Zodiac, which they call the *Annus Magnus*. But a Year is properly that Time which the Sun takes to run through the Zodiac in, and is of two Sorts, the one Astronomical, the other Civil: The Astronomical is twofold, according to the two different Bounds of the Sun's Revolution; namely, *Sydereal* and *Tropical*: the *Sydereal*

Year is the Space of Time that the Sun having departed from a fixed Star returns to the same in; and it is 365 Days, 6 Hours, and 9 Minutes, 14 Seconds. The *Tropical Year* is that wherein the Sun departing from one of the Cardinal Points, the Equinoctial or Solstitial, returns to it again, and is somewhat less than the *Sydereal*, because the Cardinal Points of the Ecliptic themselves go backwards, and as it were meeting the Sun. This *Tropical Year* is 365 Days, 5 Hours, 48 Minutes, 54 Seconds nearly, and wants about 20 Minutes of the *Sydereal*.

The Civil Year is the Space of Time that the Motion of the Sun or Moon, or both point at, received by the settled Custom of any Nation or Country, There are three Forms of the Civil Year, viz. either purely *Lunar*, or purely *Solar*, or *Lunar-Solar*, which is made up of both. The *Lunar Year* consists of twelve Lunations, or *Synodical Months*, that are finished in 354 Days, then begin again, this Year wanting near 11 Days of the *Tropical Year*, would wander through all the Seasons of the Year in about 33 Years: This Sort of Year is used among the *Turks*.

There are three Sorts of *Solar Years*, or such as are fitted to the Motion of the Sun alone, and the Vicissitudes of the Season depending thereon; the *Egyptian*, *Julian* and *Gregorian*; The *Egyptian Year* consists of 365 Days, which they divide in 12 Months, of 30 Days each, and 5 Days to be added at the End; this Year wanting near 6 Hours of the *Solar-Tropical Year*, in 4 Years it gets near a whole Day before it, and in 1460 Years its Beginning wanders through all the Seasons of the Year.

Julius Caesar finding this Year to want 6 Hours, he added the Day made of them in every 4 Years between the 23d and 24th of *February*. This *Julian Year* consisting of 365 Days, and every 4th Year of 366 Days, is best fitted for *Astronomical Computations*, because it is a Mean between the Natural or *Tropical Year* of 365 Days

Days, 5 Hours, 48 Minutes, 54 Seconds; and the Sy-
dereal Year of 365 Days, 6 Hours, and 9 Minutes.
This Year was held *common* among all polite Nations,
from *Augustus* (who restored it when almost lost) unto
the Year 1582, when the *Julian Kalender* was reform-
ed by *GREGORY XIII*; but it was still in use in
Britain and *Ireland*, &c. 'Till 1752; it must be con-
fess'd, the Quantity of our *Julian Year* was too big,
on which Account the Beginning of the Year crept
forward in Regard of the Seasons, or (which is all one,)
the Equinoxes and Solstices crept backwards, in Regard
of the Days of the Year. And since this Regrets is
about 11 Minutes, 6 Seconds, every Year, in about 130.
Years it makes a Day, and consequently from the
Year of *Christ*, 325, wherein the Council of *Nice* was
held, to the Year 1582, wherein the Pope reformed
the Kalender, namely, 1257 Years, this Regrets was
10 Days. Hence it came to pass, that whereas the
Vernal Equinox happened about the 21 Day of *March*
in the Time of the *Nicene Council*, in the Year 1582
it crept to the 11th, and in the Year 1730, it was on
the 9th Day, differing from the Ecclesiastical Vernal-
Equinox (which was the 21st of *March*) 12 Days,
which Variation was caused by our *Julian Year* exceed-
ing our *Solar Year* by 11 Minutes *near*, and the Error
was still encreasing more and more, and at length
would move out of the Limits circumscribed for *Easter*.

SECTION X.

Concerning Easter, &c. and the Vulgar Notes.

BUT the *British* Calendar being now reformed since the
Year 1752, we shall speak of *Easter*, and give some
Modern Rules for finding the Limits thereof, and the Rest
of the Moveable Feasts in the New-Style.

The Rules for fixing Easter and the other Moveable Feasts in our Common prayer Books run thus.

Easter Day, on which the Rest depend, is always the first *Sunday* after the first Full Moon, which happens upon, or next after, the twenty first Day of *March*, and if the Full Moon happens upon a *Sunday*, *Easter Day* is the *Sunday* after; Hence the earliest Paschal Full Moon in common Years happens on the 21st of *March*, or in Leap-Years, on the 20th, and the latest Paschal Full Moon is limited to *April* 18. And the Limits of *Easter* are from the 22d of *March*, to the 25th of *April* inclusive, and *Easter Day* cannot happen sooner nor later.

Septuagesima	} Sund. is	{	Nine	} Weeks be-	
Sexagesima			Eight		fore Easter.
Quinquagesima			Seven		
Quadragesima or Sunday after Ash-Wedn.			Six		

Rogation Sund.	} is	{	Five Weeks	} After Easter.
Ascension Day			Forty Days	
Whitsund. Day			Seven Weeks	
Trinity Sunday			Eight Weeks	

See an Example for finding how far the Full Moon is from the 20th of *March*, by the common Method of finding the Moon's Age, Page 158.

Now I shall give some Observations on Chronology, with Respect to the Vulgar Notes, Moveable Feasts, and other Things in Almanacks relative to the Computation of Times and Seasons, &c.

In Calendars or Almanacks it hath been usual to distinguish the seven Days in every Week throughout the Year by these seven Letters A, B, C, D, E, F, G; the first Letter A being put to the first Day of *January*, the Letter B to the second,

To find the Dominical Letter, &c. 155

cond, C to the third, D to the fourth, E to the fifth, F to the sixth, and G to the seventh; then A to the eighth, &c. in Rotation to the Year's End; the Letter answering to the first *Sunday*, (and consequently all the other *Sundays*) in the Year being called the Dominical Letter, is commonly larger than the Rest, or made Capital for Distinction.

However in such Years as are called Leap Years, (containing 366 Days) there are two Dominical Letters; one serves till the 24, or rather the End of *February* only, when the additional Day being inserted disturbs the Order of the Letters, and the Dominical is changed for the next in annual Succession, and this new Dominical Letter serves from thence to the Years End. In the Old Stile the Dominical Letters returned in the same Order every 28 Years, being governed by the Cycle of the Sun, but as the Years 1800, 1900 are now not to be considered as Leap Years, the Order of the Dominical Letters will be put out of Course at such Times.

The usual Way of finding this Letter Arithmetically is thus; take the Year, to which add its fourth Part (rejecting the Remainder) and divide the Sum by 7; and if there be any Remainder, after this last Division, subtract it from 7, and this last Remainder shews the Dominical or *Sunday* Letter till the Year 1800, counting A 1, B 2, C 3, D 4, E 5, F 6, but if there be no Remainder G is the Letter. As for Example,

For the Years 1769	1770	1771	1772
$\frac{1}{4}$ is -- 442	442	442	443
7)2211(315	7)2212(316	7)2213(316	7)2215(316
11	11	11	11
41	42	43	45
6	0 G.	1	3
6 from 7 Rem. 1 A.	1 fr. 7, R. 6 F.	3 fr. 7 R. 4 D.	

Now as there is no Remainder after dividing the Year 1772 by 4, I conclude it to be a Leap-Year, and that the Dominical found as above, viz. D, is the Letter to serve for all the *Sundays* after *February*; and that E serves only for the two first Months; for it may be noted that the Dominical Letters in annual Succession run backwards, tho' they proceed

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ceed weekly in Alphabetical Order in the Calendar. But here it must be observed as before that the Years 1800, 1900, are not to be Leap Years, tho' they may appear to be so; and their being no more than common Years disturbs the Order of the Dominical Letters in annual Succession; therefore from the Year 1800 to 1899 inclusive, it will be requisite to abate 1 in the Sum of the Year and its Fourth; and from 1900 to 2099 inclusive, to abate 2, and then proceed to find the Dominical as before.

Examples.

For 1800
The Fourth 450

2250 This Sum made less by 1, and then divided by 7, the Remainder is 2, which taken from 7, leaves 5 the Number for the Dominical Letter E, as required.

For 1900
The Fourth 475

2375 This Sum made less by 2, and then divided by 7, the Remainder is 0, which taken from 7 leaves 7 the Number answering to G, the Dominical for 1900.— And for the Year 2099, it's fourth is 524 which Numbers added, and (abating 2) divided by 7, the Remainder is 3, which take from 7, the Number 4 Remains which answers to D, for 2099, but the next Year being only a common Year, disturbs our Order again; therefore I thought proper to give Table I. which may be made perpetual, with some small Trouble. See Table I.

Having found the Dominical Letter for any Year 'tis perfectly easy to discover on what Day of the Week that Year begins, for the Letters being 7 in Number beginning with A, then which ever Letter happens to be the Dominical, shews by it's Number which of the first 7 Days of the Year is the Lord's Day or Sunday; from which we can readily reckon backwards; but, for greater Ease, we refer to Table II. and an easy Rule for finding on which Day of the Week the first of *March* in any Year happens; which Rule is thus.

To the Current Year add one fourth of itself, (rejecting the Remainder)

To find the Key-Day and Golden Number. 157

Remainder), and then 5 more; Divide the Sum by 7, this last Remainder, is the Key Day or first of *March* required, reckoning (*Sunday* or) the first Day of the Week one, *Monday* 2, *Tuesday* 3, but if nothing remain the Key Day is 7 or *Saturday*; however the Year 1800 and 1900 (tho' divisible by 4 without a Remainder) are not to be Leap-Years, but common Years, and so disturb the Order of the Key Day or first of *March* in the like Manner as they do the Dominical Letter, therefore in this Case, from 1800 to 1899 inclusive, only add 4 to the Sum of the Year proposed and its Fourth; and from 1900 to 2099 only add 3, and then divide by 7, the Remainder is the Key Day as above. But for greater Certainty see Table I. the lower Part, Page 162.

And here it may be noted, that in common Years the fourth Day of *January*, and first of *February* both fall on the same Day of the Week that the first of *March* does; but in Leap Years it will be the fifth of *January* and second of *February*: However see the lower Part of Table I. and Table III. or Perpetual Almanack, which answers the Purpose effectually, and may be continued.

The next Thing I shall take notice of is the Prime or Golden Number, said to be first found out by *Meton* an *Athenian*, about 432 Years before the Birth of Christ; it was called the Lunar Cycle or Cycle of the Moon, being a Period of nineteen Years, containing all the Variations of the Days on which the New and Full Moons happen; after which they return on the same Days as they did for 19 Years before. Now the Prime is the Number of Years elapsed at any Time in this Cycle or Revolution, and was found at our Saviour's Birth to be the Number 2. It was written in Letters of Gold, because of its Value, and sent from *Alexandria* in *Egypt* to *Rome*, and from thence called the Golden Number.

To find the Prime or Golden Number,

Add 1 to the Year proposed, and divide the Sum by 19; the Remainder is the Prime for that Year, being the same in both *Julian* and *Gregorian* Stile; as for Example, for the Year 1771 add 1, and the Sum is 1772, which divide by 19, and the Remainder is 5: but to find it more easily, See Table IV, Page 186.

The Epact is another Number very useful in many Cases to Mariners and such as observe the Moon's Course, &c.
It

158 To find the Epact and Moon's Age.

It is taken for the Age of the Moon on the last Day of the foregoing Year; and in the *Julian* Stile was always the Moon's Age on the last Day of *February*, and is thus found: *Viz.* Multiply the Golden Number by 11 and divide the Product by 30, the Remainder after dividing is the Epact (O. S.) N. B. If the Product does not amount to 30, the Product itself is the *Julian* Epact)

Now to find the *Gregorian* or New Stile Epact; subtract 11 from the *Julian* Epact, if ye can; but if not, add 30 to it and then subtract, the Remainder either way is the *Gregorian* Epact.

Example for the Year 1770.

The Prime being 4, if multiplied by 11 gives 44, and then subtracting 30, there remain 14 the *Julian* Epact; from which if we subtract 11 there remain 3, the *Gregorian* Epact for 1770. And for the Ease of such as are not expert at Figures I have added Table V. In Page 167.

Mariners having found the Epact for the Year desired, they have a Method of computing the Moon's Age to any Day in the Year, which is commonly thus: They add the Day of the Month and the Number of the Month to the Epact, and if the Sum exceeds 30 they take the Remainder for her Age, which seldom varies above a Day (but mostly none at all).

In common Years the Numbers to be added for each Month are *January* 0, *February* 2, *March* 1, *April* 2, *May* 2, *June* 4, *July* 4, *August* 6, *September* 7, *October* 8, *November* 9, *December* 10.

In Verse thus, to help the Memory.

Janur'y 0, 2, 1, 2, 2, 4, 4, 6,
7, 8, 9, 10, these to the Epact fix:
The Sum ('bate 30) to the Month-Day add;
Or take from 30: Age; or Change is had.

But for Leap-Years the Numbers of the last ten Months are each 1 more, thus,

Jan. 0, *Feb.* 2, *March* 2, *April* 3, *May* 3, *June* 5, *July* 5,
Aug. 7, *Sept.* 8, *Octob.* 9, *Nov.* 10, *Decemb.* 11.

As follow.

Examples,

To find the Moon's Southing.

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Examples.

On the 16 of *December* 1770 required the Moon's Age.

For the Day of the Month take 16
 Number of the Month 10
 Epact - - - - - 3

Sum 29 for her Age.

The Moon's Age being required for the 21 *February* 1771.

The Day of the Month is 21
 The Number of the Month, 2
 Epact - - - - - 14

37
 Subt. 30

Remains 7 The Moon's Age.

Hence by having the Moon's Age we may find at what Time she comes to the Meridian or South. (Note the New Moon Souths at Noon, and the Full Moon at Midnight.)

Rule.

Multiply her Age (if less than 15) by 4, and divide the Product by 5, the Quote gives the Hour of her Southing in the Afternoon, and the Remainder is so many Times 12 Minutes to be added. If the Moon be in the Wane or more than 15 Days old, multiply her Age the same Way by 4, deduct 12 from the Product and divide the Remainder by 5, the Quote gives the Hour of the Moon's Southing next Morning, and the last Remainder so many Times 12 Minutes.

Examples.

Required the Moon's Southing Time *January* 9, 1770.

Her Age is 12, which multiplied by 4 gives 48, and this divided by 5 Quotes 9 Hours, and the Remainder 3, gives 36 Minutes, this is for the Afternoon.

Required her Southing the 23 of *January*, 1770.

Here

166 *To find the Limits of Easter, &c.*

Her Age is 26, which multiplied by 4 gives 104, and this divided by 5 Quotes 20 Hours and 12 times 4 Minutes, answering to 8 Hours, 48 Minutes the following Morning; But this Method is not true enough for computing the Time of her Rising or Setting, by to any Certainty.

Note, When her Age is 15 ye may call it Full Moon, when 30 call it New Moon,— At the first Quarter she is 7 and $\frac{1}{2}$ Days old, and at the last Quarter 22 Days and half old.

Now to discover how far the Paschal Full Moon at any Time is from the 20th of *March*, and consequently to determine *Easter Day*; suppose for the Year 1771,

Take the Day of the Month	20
The Number of the Month	1
And add the Epact thereto	14

The Sum is 35 Which being above 30, I call the Remainder (5,) the Moon's Age on the 20 of *March*; and then taking 5 from 15 to bring her to the Full, the Remainder is 10, which added to the 20th of *March* make 30 for the Day of the Paschal Full Moon, then *Easter Day* is the very first *Sunday* after, viz. on the 31 of *March* 1771, as may be proved from Table VI. where I find the Number of Direction is 10, which being added to *March* 21 makes 31.

Now if any Person should demand on what Day *Easter* falls in the Old Stile, do thus: Multiply the Prime for that Year by 11, the Sum if under 30, or Remainder if above thirty (is the Epact, Old Stile, and) is to be added to the 21 of *March*, and this last Sum if under 30, or Remainder if above 30, shews the Age of the Moon for the 21 of *March* Old Stile; and if the 15th Day of her Age be upon or after the 21 of *March* the very next *Sunday* is *Easter Day*: But in Case the 15th Day of the Moon's Age (in such Trial as above) falls on any Day before the 21 of *March*, we must add 30 Days more to find the next Full Moon that immediately comes before *Easter*.

An Example for the Year 1770.

The Prime 4 multiplied by 11 gives 44, the Complement whereof to 30 being 14 makes the Epact, (Old Stile), for 1770: Then to *March* 21st if we add 14 it makes 35 which answers to *April* the 4th (Old Stile), and corresponds with the 15th of *April*, New Stile, which happens to be *Sunday*, and the very *Easter* Day in both Accounts; which seems to be greatly mistaken in the Gentleman and Citizens Almanack for *Dublin* 1770.

And now having shewn how to find these Vulgar Notes; &c. I shall proceed to shew the same by several useful and ready Tables.

SECTION XI.

Containing several useful Chronological Tables for finding the Vulgar Notes and moveable Feasts, &c.

TABLE

TABLE I.

Shewing the Dominical Letter in the Gregorian or New Stile, from 1600 till the Year 3100. And it likewise shews on what Day of the Week the first Day of March happens in any Year.

Even Hund. of Years				Dominical Letters.						
1600	2000	2400	2800	A	G	F	E	D	C	B
1700	2100	2500	2900	C	B	A	G	F	E	D
1800	2200	2600	3000	E	D	C	B	A	G	F
1900	2300	2700	3100	G	F	E	D	C	B	A

The Use of the upper Part of this Table.

The Even or Whole Hundreds of Years stand in the Columns on the Left Hand at Top; and under the Dominical Letters on the Right Hand, stand the odd Years in every Century or Hundred, so that in the Angle meeting between the Century past and the odd Years, we find the Dominical Letter for the Year proposed.

Example.

For the Year 1770; look first in the Left Hand Columns at Top for 1700, and then in those on the Right for 70; in the Angle meeting above we find G, the Dominical Letter for that Year.

Again, in the Angle meeting above between 1700 and 72 we find D for the Year 1772.

—	1	2	3	—	4	5
6	7	—	8	9	10	11
—	12	13	14	15	—	16
17	18	19	—	20	21	22
23	—	24	25	26	27	—
28	29	30	31	—	32	33
34	35	—	36	37	38	39
—	40	41	42	43	—	44
45	46	47	—	48	49	50
51	—	52	53	54	55	—
56	57	58	59	—	60	61
62	63	—	64	65	66	67
—	68	69	70	71	—	72
73	74	75	—	76	77	78
79	—	80	81	82	83	—
84	85	86	87	—	88	89
90	91	—	92	93	94	95
—	96	97	98	99	—	—
1600	2000	2400	2800	4	5	6
1700	2100	2500	2900	2	3	4
1800	2200	2600	3000	7	1	2
1900	2300	2700	3100	5	6	7
Even Centuries.				First Days of March.		

Use of the lower Part of Table I. p. 162.

To know on which Days of the Week *March* begins by this Table: Find as before, the even hundreds of Years in the Left Hand Columns below; and then under the Dominical Letters find the odd Years, and in the Angle meeting below, we have the Day of the Week on which *March* begins for that Year.

Example for the Year 1770.

I find 1700 on the Left Side, and 70 in the Columns under the Dominical Letters; in the Angle meeting I get 5, for the 5 Day of the Week (or *Thursday*) on which *March* begins 1770.

For the Year 1802.

In the Angle meeting between 1800 and 2, I get 2 for the second of the Week or *Monday*; and for 1778 I get 1 for *Sunday*, &c.

Observe that such odd Years as have this Mark (—) or Dash before them are Leap-Years, and have two Dominical Letters; as in the Year 1772, D serving from the End of *February* to the Year's End, and the Letter that lies next before it, and over the Dash, for the two first Months only, which in this Case is E. And every fourth Year is to be called Leap-Year, except the even Hundreds or Centuries past in the three undermost Lines (either above or below) beginning with 1700, 1800, 1900.

When the Dominical is found, either by the above Table or by Rule, the first Lord's Day in every Month is easily found also by the following Table; and consequently all the other Lord's Days.

TABLE

orian
100.
Week
ar.

tters.	
C	B
E	D
G	F
B	A
4	5
10	11
—	16
21	22
27	—
32	33
38	39
—	44
49	50
55	—
60	61
66	67
—	72
77	78
83	—
88	89
94	95
—	—
—	—
2	3
7	1
5	6
3	4
arch.	

TABLE II. *Shewing on which Days in every Month the several Lord's Days happen.*

January 1 mo.	2	3	4	5	6	7	8	9	10	11	12					
January	February	March	April	May	June	July	August	September	October	November	December					
a	d	d	g	b	e	g	c	f	a	d	f	1	8	15	22	29
b	e	c	a	c	f	a	d	g	b	e	g	2	9	16	23	30
e	f	f	b	d	g	b	e	a	c	f	a	3	10	17	24	31
d	g	g	c	e	a	c	f	b	d	g	b	4	11	18	25	.
e	a	a	d	f	b	d	g	c	e	a	e	5	12	19	26	.
f	b	b	e	g	c	e	a	d	f	b	d	6	13	20	27	.
g	c	c	f	a	d	f	b	e	g	c	e	7	14	21	28	.

Example for common Years.

Suppose the Year 1773.

Having found that the Dominical for 1773 is C. I look under *January* and find C, opposite to which on the Right Side of my Table I have 3, 10, 17, 24, 31 for the several Lord's Days in the Month of *January* 1773. Again under *February* I find C, opposite which on the Right Hand I find in a Line 7. 14. 21. 28 for the Lord's Days in *February*. And in like Manner, under each respective Month in the Year, the Dominical directs to the several Lord's Days in the Month, in Lines on the Right Side of the Table. But in

Leap Years which have 2 Dominicals, use the first for the Months of *January* and *February* only; and the second for *March* and the Rest of the Year; thus the Dominicals for 1772 are E and D. And under *January* having found E, I have in the Line opposite to it, 5. 12. 19. 26 for the several Lord's Days in *January*. And opposite to E that stands under *February* I get 2. 9. 16. 23 for the Lord's Day in *February*. But when I come to *March* I must find D under it, and take the Numbers opposite thereto, viz. 1. 8. 15. 22. 29.

A Table of this Kind may be formed after another Manner, without the Dominical Letters, and called a Perpetual Almanack for finding the Day of the Week, that the Month of *March* or any other Month begins on, which answers very well in all common Years; but in Leap Years great Care is

TABLE &c.

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to be taken in the Months of *January* and *February*; that is, to put the Lord's Day therein one Day more forward, on Account of the Day added in *February*, for which Purpose we have adjoined two additional Columns, for *January* and *February* in Leap Years only.

Perpetual Almanack or TABLE III.

For common Years.							For Leap Y.	
<i>Janu.</i> <i>Octo.</i>	<i>Mar.</i> <i>Febr.</i> <i>Nov.</i>	<i>Apri.</i> <i>July</i>	<i>May</i>	<i>June</i>	<i>Aug.</i>	<i>Sept.</i> <i>Dece.</i>	* <i>Janu.</i>	* <i>Febr.</i>
4	1	5	3	7	2	6	5	2
11	8	12	10	14	9	13	12	9
18	15	19	17	21	16	20	19	16
25	22	26	24	28	23	27	26	23
..	29	..	31	..	30	..	..	..

The Use of this Table is easy.

We have already in Page 166, 167, given a Rule to find the Key Day, or Day of the Week on which *March* begins in any Year, and also shewn the same in Table I. which being known, look under the Month *March* in this Table where we find 1. 8. 15. 22. 29 which several Days in *March* will all be on the same Day of the Week that the Key Day is: Likewise the Days of the Month under each particular Month, will all be on the same Day of the Week that the first of *March* is.

As for Instance, In the Year 1770, the first of *March* or Key Day happens on 5th of the Week (or *Thursday*) therefore the 1. 8. 15. 22 and 29th of *March*, *February* and *November*: Are all on *Thursdays*, and consequently the 4. 11. 18 and 25 of *January* and *October* are also on *Thursdays*, and so of the Rest; except in Leap Years as aforesaid, in the Months of *January* and *February* only, and then the Columns of Figures for Days of the Month under *January* and *February* should stand as we have placed them on the Right Side of the Table; but Leap Year makes no Variation in the latter Ten Months.

Here follows a Table of the Cycle of the Moon or Golden Number continued from the Birth of CHRIST 'till 3799, being the same in both Accounts.

TABLE

T A B L E IV. Shewing the Prime or Golden Number.

Since CHRIST the odd Years for ever	1800	1700	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	400	300	200	100	000	1900
0 1938 577695	15	10	5	19	14	9	4	18	13	8	3	17	12	7	2	16	11	6	1	6
1 2039 587796	16	11	6	1	15	10	5	19	14	9	4	18	13	8	3	17	12	7	2	7
2 2140 597897	17	12	7	2	16	11	6	1	15	10	5	19	14	9	4	18	13	8	3	8
3 2241 607998	18	13	8	3	17	12	7	2	16	11	6	1	15	10	5	19	14	9	4	9
4 2342 618099	19	14	9	4	18	13	8	3	17	12	7	2	16	11	6	1	15	10	5	10
5 2443 6281	1	15	10	5	19	14	9	4	18	13	8	3	17	12	7	2	16	11	6	11
6 2544 6382	2	16	11	6	1	15	10	5	19	14	9	4	18	13	8	3	17	12	7	12
7 2645 6483	3	17	12	7	2	16	11	6	1	15	10	5	19	14	9	4	18	13	8	13
8 2746 6584	4	18	13	8	3	17	12	7	2	16	11	6	1	15	10	5	19	14	9	14
9 2847 6685	5	19	14	9	4	18	13	8	3	17	12	7	2	16	11	6	1	15	10	15
10 2948 6786	6	1	15	10	5	19	14	9	4	18	13	8	3	17	12	7	2	16	11	16
11 3049 6887	7	2	16	11	6	1	15	10	5	19	14	9	4	18	13	8	3	17	12	17
12 3150 6988	8	3	17	12	7	2	16	11	6	1	15	10	5	19	14	9	4	18	13	18
13 3251 7089	9	4	18	13	8	3	17	12	7	2	16	11	6	1	15	10	5	19	14	19
14 3352 7190	10	5	19	14	9	4	18	13	8	3	17	12	7	2	16	11	6	1	15	20
15 3453 7291	11	6	1	15	10	5	19	14	9	4	18	13	8	3	17	12	7	2	16	21
16 3554 7392	12	7	2	16	11	6	1	15	10	5	19	14	9	4	18	13	8	3	17	22
17 3655 7493	13	8	3	17	12	7	2	16	11	6	1	15	10	5	19	14	9	4	18	23
18 3756 7594	14	9	4	18	13	8	3	17	12	7	2	16	11	6	1	15	10	5	19	24

A Table of the Gregorian Epacts. 167

To find the Golden Number or Prime by the foregoing Table.

First seek the Century or even Hundreds at Top, (or first Side Column as the Page stands) and then seek the odd Years or Parts of 100 in the Columns of odd Years since *Christ*, and in the Angle meeting we have the Answer: Thus for the Year 1771, I find 1700 above the last Column but one on the Right Side of the Table, and 71 stands in one of the Left Hand Columns (near the Bottom of the Page,) and in the Angle meeting we have 5, the Prime sought for 1771.

TABLE V.

Gregorian Epacts from Century 1500 to 3200.

To find the Gregorian Epact by this Table.

First having found (by the foregoing Table) the Prime or Golden Number, look in the Column under Golden Numbers for it, and then in the same Line under the Century past, or even Hundreds fitted to it, ye have the Epact for the Year required, N. S.

Example for the Year 1772.

The Golden Number I find is 6 by the foregoing Table, which I look for in the Column under Golden Number here, and then opposite thereto, under the Centuries ending 1700 to 1900 I get 25 the Gregorian Epact for 1772.

Golden Numbers.	1500 to 1700	1700 to 1900	1900 to 2200	2200 to 2500	2500 to 2800	2800 to 3200
1	1	0	29	28	17	26
2	12	11	10	9	8	7
3	23	22	21	20	19	18
4	4	3	2	1	0	29
5	15	14	13	12	11	10
6	26	25	24	23	22	21
7	7	6	5	4	3	2
8	18	17	16	15	14	13
9	29	28	27	26	25	24
10	10	9	8	7	6	5
11	21	20	19	18	17	16
12	2	1	0	29	28	27
13	13	12	11	10	9	8
14	24	23	22	21	20	19
15	5	4	3	2	1	0
16	16	15	14	13	12	11
17	27	26	25	24	23	22
18	8	7	6	5	4	3
19	19	18	17	16	15	14

TABLE

TABLE VI.

Shewing the New-Style Number of Direction, which readily points out when Easter Day, and the other moveable Feasts happen.

Pri.	A	B	C	D	E	F	G
1	26	27	28	29	30	24	25
2	19	13	14	15	16	17	18
3	5	6	7	8	2	3	4
4	26	27	21	22	23	24	25
5	12	13	14	15	16	10	11
6	33	34	35	29	30	31	32
7	19	20	21	22	23	24	18
8	12	13	7	8	9	10	11
9	26	27	28	29	30	31	32
10	19	20	21	15	16	17	18
11	5	6	7	8	9	10	4
12	26	27	28	29	23	24	25
13	12	13	14	15	16	17	18
14	5	6	7	1	2	3	4
15	26	20	21	22	23	24	25
16	12	13	14	15	9	10	11
17	33	34	28	29	30	31	32
18	19	20	21	22	23	17	18
19	12	6	7	8	9	10	11

To use this Table.

First find the Dominical Letter for the Year proposed by Table I. also the Prime or Golden Number Table IV. Then in the Angle meeting between the Dominical at Top, and the Prime in the Left Hand Column we have the Number of Direction; as for Instance; in the Year 1771 the Dominical is F and the Prime 5, then in the Angle meeting we get 10 the Number of Direction for 1771. In like Manner the last Dominical for 1772 is D, and the Prime 6, which give 29 in the Angle meeting for the Number of Direction 1772.

Now if the Number of Direction be added to the following Dates, the Sum shews the Time of the moveable Feasts for that Year.

To January	31	} Add the Number of Direction and you get	Shrove Sunday.
February	3		Asb Wednesday.
March	21		Easter Sunday.
April	25		Rogation Sunday.
April	29		Ascension Day.
May	9		Whitsunday.
May	16		Trinity Sunday.
May	20		Corpus Christi.

T A B L E

TABLE VII.

A TABLE Shewing, by means of the Golden Numbers, the several Days whereon the Paschal Limits, or Full Moons, in the Gregorian Account, have happened or may happen from the Year 1583—till the Year 3399 inclusive; and the Dominical Letter for the Year proposed shews how far the next succeeding Sunday (or Easter) is distant.

Go. N ^o . from the Yrs. 1583 to 3399 inclusive										Pasch. F. Moons
1583 to 1699	1700 to 1899	1900 to 2199	2200 to 2399	2300 to 2499	2400 to 2599	2500 to 2699	2600 to 2899	2900 to 3099	3100 to 3399	Days of the Month and Sunday Letters.
3	14	—	6	17	6	17	—	9	—	March 21 C 22 D 23 E 24 F 25 G
—	3	14	—	6	—	6	17	—	9	
11	—	3	14	—	14	—	6	17	—	
—	11	—	3	14	3	14	—	6	17	
19	—	11	—	3	—	3	14	—	6	
8	19	—	11	—	11	—	3	14	—	26 A 27 B 28 C 29 D 30 E
—	8	19	—	11	—	11	—	3	14	
16	—	8	19	—	19	—	11	—	3	
5	16	—	8	19	8	19	—	11	—	
—	5	16	—	8	—	8	19	—	11	
13	—	5	16	—	16	—	8	19	—	April 31 F 1 G 2 A 3 B 4 C
2	13	—	5	16	5	16	—	8	19	
—	2	13	—	5	—	5	16	—	8	
10	—	2	13	—	13	—	5	16	—	
—	10	—	2	13	2	13	—	5	16	
18	—	10	—	2	—	2	13	—	5	5 D 6 E 7 F 8 G 9 A
7	18	—	10	—	10	—	2	13	—	
—	7	18	—	10	—	10	—	2	13	
15	—	7	18	—	18	—	10	—	2	
4	15	—	7	18	7	18	—	10	—	
—	4	15	—	7	—	7	18	—	10	10 B 11 C 12 D 13 E 14 F
12	—	4	15	—	15	—	7	18	—	
1	12	—	4	15	4	15	—	7	18	
—	1	12	—	4	—	4	15	—	7	
9	—	1	12	—	12	—	4	15	—	
—	9	—	1	12	1	12	—	4	15	15 G 16 A 17 B 18 C
17	—	9	—	1	—	1	12	—	4	
6	17	17	9	—	9	—	1	12	12	
14	6	6	17	9	17	9	1	1	1	

Use of this Table.

First, chuse out the Period at the Top, in which the Year proposed is contained, then in the Column under it, find the Golden Number for the same Year; over against which in the same Line continued to the Column of Paschal Full Moons, we have the Month and Day that the Paschal Full Moon falls on, and the Letter adjoined shews the Day of the Week, and of consequence the Day that stands next with the Dominical Letter for that Year, is *Easter Sunday*.

Example.

In 1770, The Golden Number is 4, which I find under 1700, &c. then to the Right Hand in the same Line, and under Paschal Full Moons, I get *April 10 B*. But the Dominical Letter being G, I find it stands at *April 15* for *Easter Sunday*, and B denotes the 10th Day to be *Tuesday* or 3d Day of the Week.

Again, in 1771, the Golden Number is 5, against which is *March 30*, and the Dominical Letter is F standing against *March 31*, or *Easter Day*.

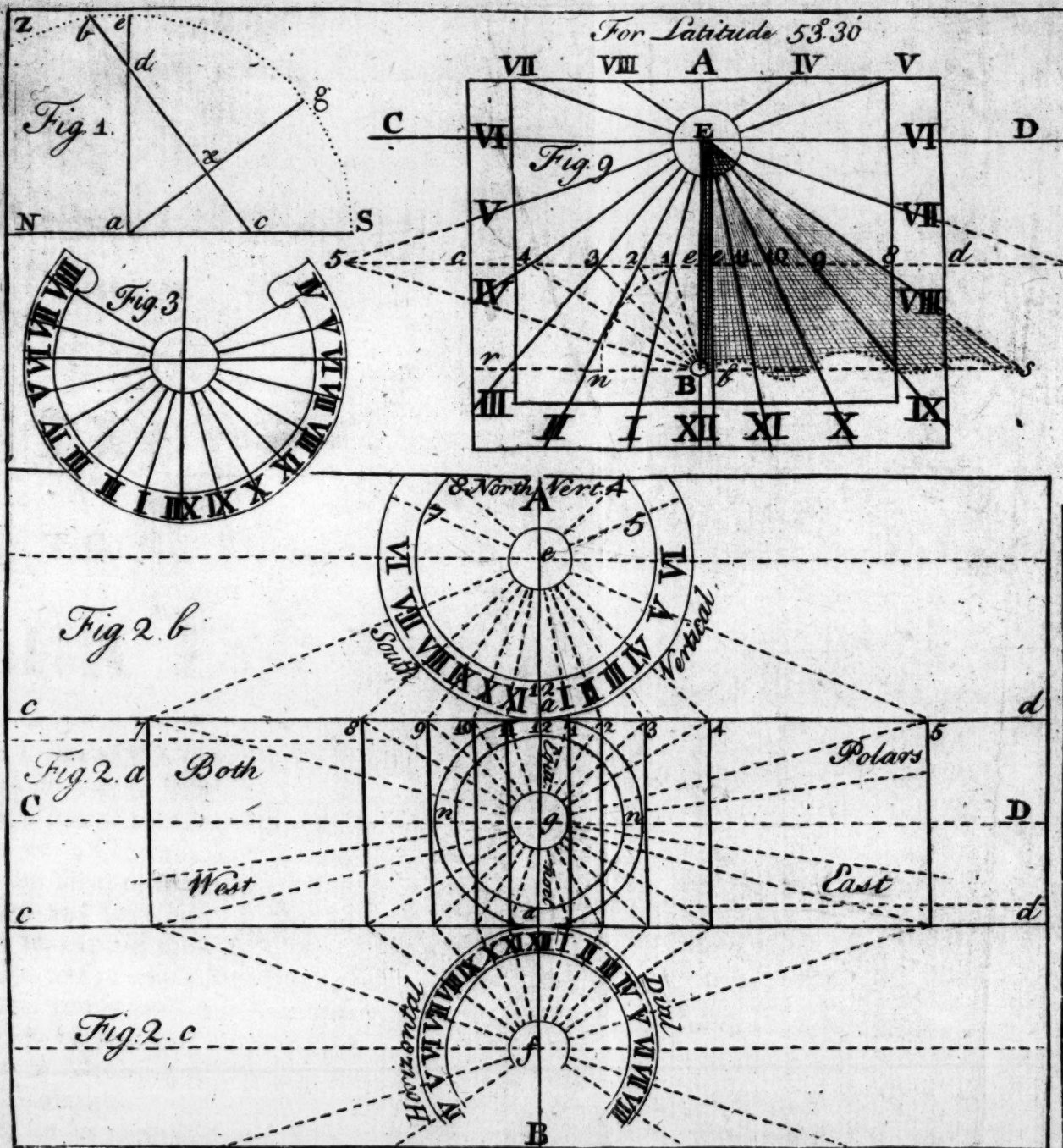
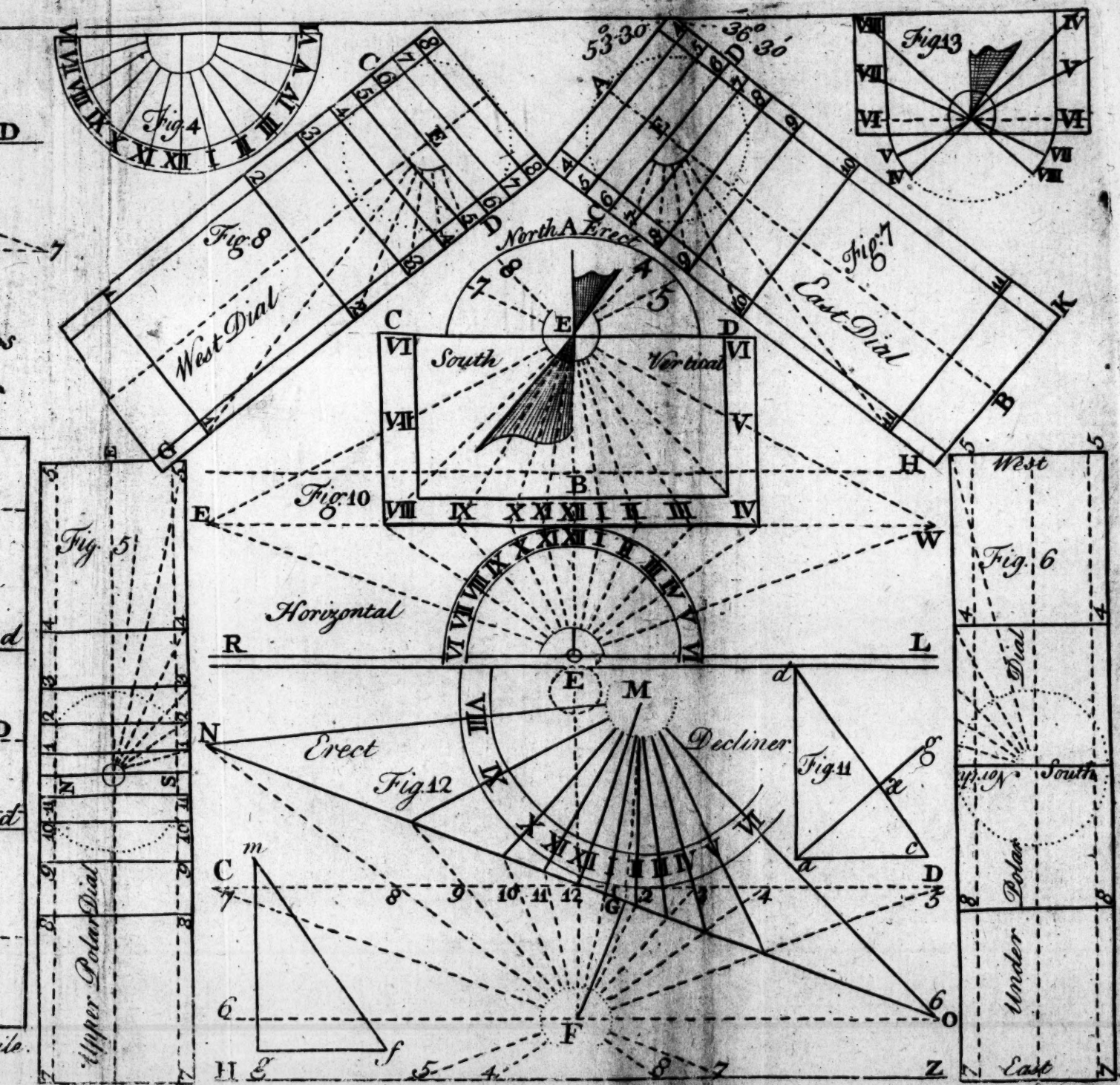
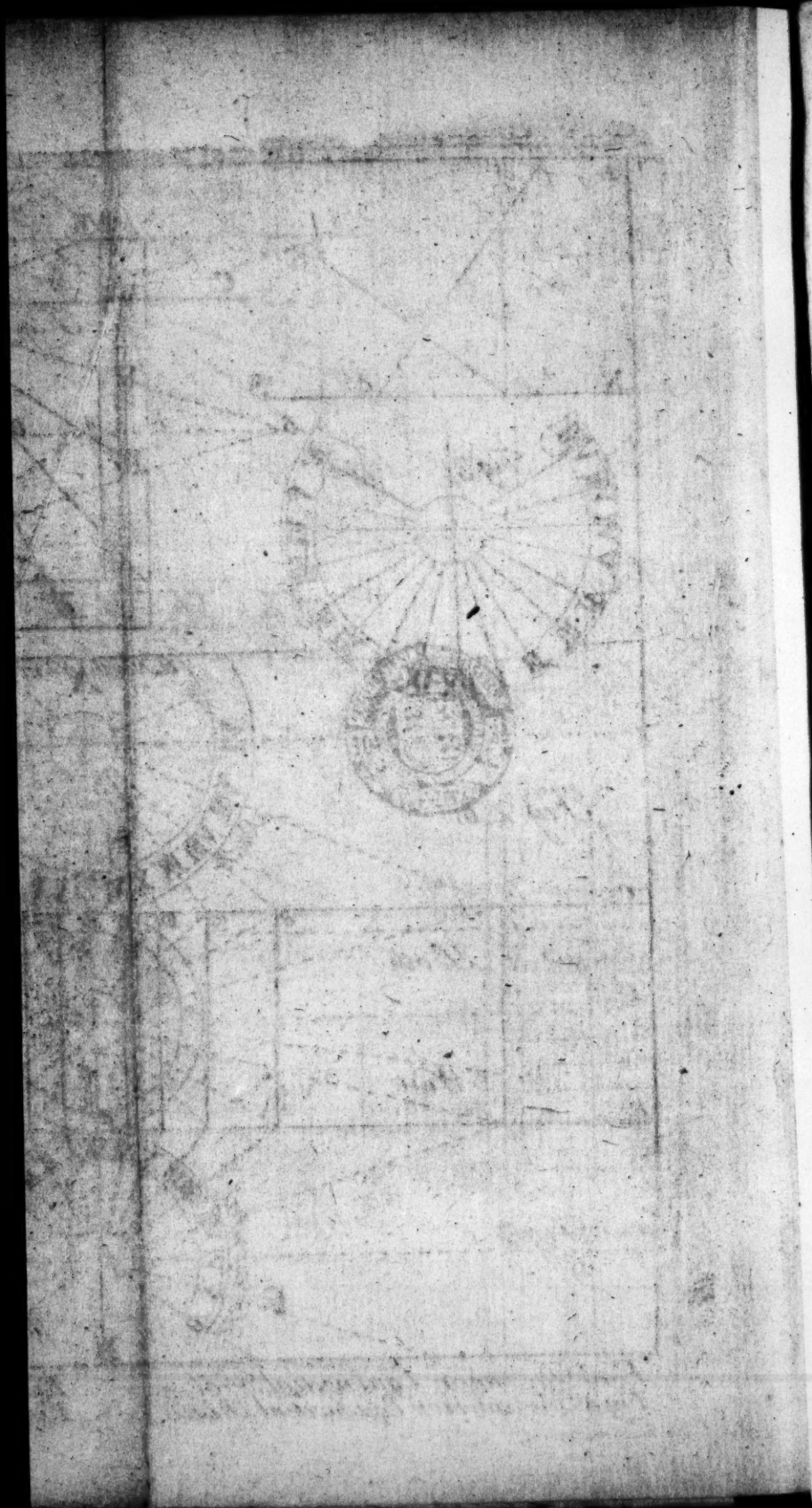


Fig 3 The upper Equinoctial Dial.
Fig 4 The inferior Equinoctial Dial.

Fig 9 Horizontal Dial with its Style.
Fig 5 A North Erect Dial.





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AN
INTRODUCTION
TO THE ART OF
DIALLING

THE Art of Dialling, by some called Horography, or the Art of Shadows, is the Art of shewing the Hour or Time of the Day when the Sun shines, by the Shadow of a Gnomon or Pin set up for that Purpose (called the Stile) or some other Contrivance to shew the Elevation and Direction of the Sun; but here I only propose to explain the chief Principles, as an easy Introduction to the whole System, by laying down a few Rules and giving pertinent Examples; by which common Dials of any kind may be projected for any Latitude, in a Mechanical Manner, without any troublesome Calculation.

First, let us premise thus: If a Line be stretched (suppose a Piece of streight Wire) and fixt Parallel to the

the Axis of the World, and then again, if this Line be made to pass through the Center of a Circle drawn upon a smooth Plane, Plate or Board, fixt every Way at Right-Angles to the abovesaid Line, such Circle will then represent, or be parallel to the Plane of the Equator; and the said Line will also point to the Poles of the World, and at once shew the Latitude, and Elevation of the Pole, and the Direction of Stiles of Dials in general.

Again, As the Sun seems to be carried round the Globe, (and its Axis) with equal Motion once in 24 Hours, by the Diurnal Rotation of the Earth. I say, if the said Circle be divided into 24 equal Parts (or rather twice 12) each Part containing 15 Degrees, the Distance of the Hour Lines asunder, beginning at the Vertex, or most southern Part, and proceeding Westward (as in Fig. 2.) the Shadow then of the Stile or Wire upon these equal Divisions will shew the corresponding Time, or Hour of the Day, perpetually as it passes round;—and not only so, but said Shadow may be transferred to any other Plane contiguous or conveniently applied to any Side of the said Circle, which in the above Position may be truly called an Equinoctial Dial; and from which I have drawn the Fundamentals or a Diagram for forming most other plain Dials, (as *per* Fig. 1. Plate III or last.)

Or, Suppose we take an artificial Globe, and rectify it to our Latitude, and then place it so that the Axis shall point to the two Poles of the World, and a Portion of it project a little above the Hour Index, 'tis plain that the Shadow of the Axis when the Sun shines will point to, or measure out, the Hours of the Day upon the Hour-Circle; and not only so, but, if any other Plane be applied to the Globe in that Position, the Shadow that falls upon 10, 11, 12, (or any other Hour mark'd upon the Hour Circle,) will mark where the same corresponding Hour should be drawn upon the said applied Plane, and the same Stile serve for each.

Again,

Again, supposing the Globe still in the same Position, and the Equinoctial Line divided into twice 12 equal Parts, each 15 Degrees; the Sun will always enlighten one half of the Globe when he shines, and if the Hours be properly placed on the Equinoctial Line on the Globe, the Edge of the enlightened Part will shew the Hour of the Day in two opposite Places at once; Note, the Numbers for the Hours in this Kind of Dial are to be so placed that one VI. may stand under, or on the Meridian, and the other VI. diametrically opposite.

Now, we shall shew how to form Fundamentals, (having the Latitude given,) for drawing the Equinoctial Dial, also both Polars, and East and West Dials; and then, from the Equinoctial, to frame the horizontal and direct Vertical South and North Dial, or any other upright declining Dial, without any Instruments but a Scale or Rule with a Line of Chords, and a Pair of good Compasses: And in case a Scale of Chords be wanting, a Protractor may serve very well, especially for dividing the Arch of a Circle.

Example I. To form the Fundamental Diagram.

First, Draw the Meridian Line N. S, to represent a North and South Horizontal Line. (Fi. 1. Pl. III. or last.)

2. Draw the Arch *z, e, s*, to represent the Meridian in the Heavens.

3. Erect the Perpendicular *a, e*, to represent the Vertical Plane.

4. From *s* to *g* set off the Complement of the Latitude given, or Elevation of the Equator, (which for Example we will suppose $36^{\circ}. 30'$) and draw *ag* to represent the Plane of the Equator.

5. Take Half the Diameter of the Circle intended for inscribing your Equinoctial Dial and set it off from *a* to *e* on the Line *ag*; then through the Point *e*, and at Right Angles to the Line *ag*, draw the Line *cedb*; then will the Line *cd* represent the Elevation of the

Pole or Earth's Axis ; and will stand in the general Position or Direction for the Stiles of all those Dials above mentioned, and all other common Dials, (the Polar excepted). And we may observe from this Fundamental Figure, that $b d$, is the Stile for the North Vertical, $d a$, for the South Vertical Plane ; and $c d$ is for the Stile of the Horizontal ; the Angle $a c d$ being equal to the Latitude, and the Angles $a d c$ and $b d e$ both equal to the Complement ; and now the Fundamental being finish'd, take the following Example to draw the Æquinoctial Dial, for framing the Rest to this given Latitude, viz. $53^{\circ} 30'$.

Example II. To form the Æquinoctial Dial.

1. Draw the Line $A B$ for a Meridian Line, (Fig. 2. a .), and at Right Angles thereto (through the Center g) draw the Line $C D$; then at the Distance or Extent $a a$, on the Equinoctial Line $a a g$, taken from the Fundamental (in Fig. 1.) with one Foot of a Pair of Compasses placed in the Center g , draw the obscure Circle $a n a n$, and divide its Circumference into 24 equal Parts, (or each Quadrant into 6,) each 15 Degrees, for the Hour Distances, which may be conveniently done with a Protractor, and again subdivided into Half Hours and Quarters. Next, through the two extreme Points at a and a , draw the two equidistant Lines $c d$ and $c d$, each parallel to the Line $C D$, (which may be called Contingents) and then, from the Centre g , extend straight Lines through the equidistant Divisions in the Circumference, till they meet the Lines $c d$ and $c d$ (which they all will except the Line of 6, or $C g D$;) which being done, our Equinoctial Dial is drawn, and contains the Hour Lines of both the Polar Dials, and the East and West Dials ; but the Manner of numbering the Hour Lines, and fixing such Dials up for Use, may require some particular Directions, which shall be given further on.

Note,

Note, This Equinoctial Dial would become a Horizontal Dial if placed under the Pole, provided the Projector were skilful enough to find the Meridian.

Example III. From the Equinoctial to form the Horizontal Dial.

Take the Length of the Line or Extent ac in the Fundamental (Fig. 1.) and set it off (on the Line aB) from a Southwards to f (in Fig. 2. c .) then from f draw streight Lines to the Intersections 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5, on the under Line cd , and these Lines will be the Hour Lines of your Horizontal Dial from 7 in the Morning till 5 in the Evening; and a Line drawn through the Centre g parallel to the Line CD gives the Hour Lines of 6; and lastly for the Hour Lines before 6 in the Morning, and after 6 in the Evening, if we extend the opposite Hour Lines through the Centre f (the Point from whence the Stile is to project) to the contrary Side, we obtain the Morning Hour Lines of 4 and 5, as well as the Evening Hour Lines 7 and 8. And with Respect to the Figures indicating the Hours, they may be inscribed between Circles, (as in this Figure) or otherwise in a Square or any Kind of Polygon; and as for the Stile it must always be directed to the Pole, and answer to the Latitude of the Place. (See Figure 2. c and) Fig. 9.

Example IV. To describe the South and North vertical Dials in like Manner, for the same Latitude.

Take from the aforesaid Fundamental (Fig. 1.) the Length or Extent ad from the Line ae and set it off, on the Line BA , in Fig. 2. b , from a to e ; then from e (the Point where your Stile is to enter your Plate) draw Lines to the several Intersections on the upper

Lines of your South Dial from 7 in the Morning till 5 contingent Line *c d*, and these will be the several Hour in the Evening; and as for the Line of 6 Morning and Evening, draw it (through the Point or Centre *e*,) parallel to the Line *CD*. The Height of the Stile is the Complement of Latitude, and points downwards towards the South Pole, (see Fig. 10.)

Example V. To describe the North Vertical Dial.

First we are to consider that the North Vertical Dial will only shew the Hour of the Day before the Sun comes East in the Morning, and after he comes West in the Evening, and therefore appears to be useless in Winter: The Hour Lines may be easily obtained by extending through the Center, those that lie opposite next to the Hour Lines of 6, in the above Projection of the South Vertical; but then as the North Vertical Dial is to be placed (as it were) on the Back of the South Vertical, the Numbers are to be reversed. (See Figure 13.) The North Dial is no more than the South Dial turned upside down, facing the North, the Hours properly numbered as above-mentioned, and continued below the Line of 6, 6, as far as 4*b.* 45*m.* Afternoon, and 7*b.* 15*m.* Morning, (if for the Latitude of *Dublin*,) which are the Times the Sun comes East and West at the Summer Solstice, in that Latitude; and the Hour-Lines between 8*b.* 28*m.* Afternoon, and 3*b.* 32*m.* Morning may be omitted, being the Times of latest Sunset and earliest Sunrise in that Parallel, (allowing for Refraction.)

Example VI.

As Equinoctial Dials are of different Kinds, it may be necessary to say something farther about them, and in Example 2. (Fig. 2. *a.*) we have given the Way of drawing such, but they may be placed some on the upper Side of the Plane, and some on the under; therefore we have given the Representation of the upper Face (Fig. 3.) and of the under Face (Fig. 4.) and observe,

serve, the Stile of each is to be projected or set up perpendicular to their Planes, and the upper Face will shew the Time from Sun-rise till Sun-set in Summer, and the under Side only serves from the 22 of *September* till the 20 of *March*, and need not have any Lines drawn to serve either before or after 6.

Note, If the Face of the upper Side be drawn on thin Paper, the Backside shews the under Face, but the Figures denoting the Hours must be reversed, (as per Fig. 4.)

Example VII. To draw the Face of the upper Polar Dial.

A Polar Dial is such, that the Plane on which it is described lies parallel to the Axis of the World, and at right Angles to the Plane of the Meridian; the Stile standing Perpendicular to the Dial-plane, and like all other Stiles, in the Plane of the Meridian, and the Edge of it parallel to the Earth's Axis; and may be thus projected, for the upper Side.

1. Draw the Transverse Line W. E. (Fig. 5.) and at Right Angles thereto, about the Middle, draw another Transverse Line as N. S. cutting the former in $\odot$; then from the Center $\odot$ describe an obscure Circle, which the Lines W. E. and N. S. will divide into 4 Quadrants: One of which Quadrants divide into 6 equal Parts, and draw two Right Lines (as Tangents to the Circle) parallel with the Line W. E. If then from the Center $\odot$, through the Points of the divided Quadrant, be drawn obscure Lines as far as the Contingent Line last drawn, they will determine in the Point of Intersection the unequal Spaces of your Hour Points: And when the four Quadrants are divided in like Manner, and Lines drawn from the Center $\odot$ to the Contingent Lines on both Sides, and number'd from the Points N. S. Eastwards 12, 1, 2, 3, 4, 5; and Westwards 12, 11, 10, 9, 8, 7; it only then remains to finish the

Dial by drawing the Lines 5...5, 4...4, 3...3, 2...2, 1...1, 12...12, &c. And in placing the Dial for Use put E. towards the East and W. towards the West, that N. may point North and S. South: The Stile may be a Piece of straight Wire, its Height equal to the Radius of the obscure Circle or Quadrant above, and being placed Perpendicular to the Plane of the Pole, in the Centre $\odot$, the Shadow of it's Point falling among the Hour Lines numbered as in the Figure, will determine the Hour of the Day, (see Fig. 5.)

Note, A Polar Dial may serve for a Horizontal Dial, when it is placed Horizontal and due East and West under the Equinoctial Line, and the Stile may be made to stretch from Side to Side, at the Distance $\odot$ S. or Radius of the obscure Circle. In looking at the upper Polar Dial in its Position our Backs are to the South.

Example VIII. To delineate the Hour Lines upon the under Side, or the inferior Polar Dial.

Suppose the upper Polar delineated or drawn upon a Piece of thin Paper, the Hour Lines of the inferior Side would appear upon the Back thereof, but then we should have no Occasion for the Hour Lines between 6 in the Morning and 6 in the Evening, because such a Dial would be quite useless in Winter: But the Hour Lines before and after 6 are the same in both kinds as may be observed in the Figure, provided they be made to fall upon the Back of each other properly; the Stile to the Inferior being equal in Length to the Stile of the other, (see Fig. 6.) In Latitudes near either Pole, such a Dial may be of some Use, but under the Equinoctial Line is of no Service.

Note, Both the upper and under Polar Dials are contained in the Projection of the Equinoctial (Fig. 2. a.) only the numbring of the Hour Lines wants a little Explanation, which may be better understood by looking
here

here at Fig. 5 and 6. In looking at the under Polar Dial in its first Position, our Backs are towards the North.

Example IX. Shewing how to delineate an East Dial.

The East Dial is to be drawn upon an upright Plain directly facing the East, therefore first to determine the genuine Position of your Dial, draw on the Wall a Horizontal Line, then on a flat Board, Plate or Piece of Paper draw another Line to represent it, (as G H Fig. 7.) upon this Line at some convenient Place or Point (suppose H) make a Point and draw the Line H C, making the Angle G H C equal to the Complement of your Latitude, or Elevation of the Equator (in this Example 36 .. 30 N.) and in the Line H C chuse out a Point (suppose C) leaving Space enough below for all the Hour Lines between 6 in the Morning and a Quarter of an Hour before Noon to lie above H. Then from C draw the Line CD perpendicular to CH. And from a Fundamental Diagram form'd as Fig. 1. take the Distance $a\epsilon$ on the Equinoctial, and set it off from C to E, and from E as a Centre, describe an obscure Circle through C, which Circle will be divided into 4 Quadrants by the crossing of the Lines CD, and A B in E, at Right Angles. Divide one of these Quadrants (suppose C I) into 6 equal Divisions, and draw a Contingent Line at the Distance of C E, parallel to the Line CH and A B, through the Point D to K. Next, through the several Points of equal Division, on the Quadrants of the Circle, draw from the Centre E streight Lines till they intersect the Contingent Lines on each Side, then from these Points of Intersection draw the Hour Lines 6 6, 7 7, 8 8, 9 9, 10 10, 11 11, &c. which with Respect to their Distances agree exactly with the Eastern or Right Portion of the upper Polar Dial, and it requires a Stile of the same Height the Polar does, (*viz.* the Extent $a\epsilon$ taken from the

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Fundamental Fig. 1.) but then in the numbring the Hours, observe that the 12 o'Clock Line in the Polar is to be mark'd 6 in the East Dial, and the next above it are 5 and 4 to be drawn at the same Distance above as the Hour Lines of 7 and 8 are below ; the Hour Lines below being 7, 8, 9, 10, 11, &c. but the Shadow goes off before 12, and in a Quarter of an Hour after 12 may be perceived on the West Dial, if there be Space enough on the Walls. (See Fig. 7.)

Example X. In drawing the West Dial.

If an East Dial be delineated on a thin Piece of Paper, the West Dial will appear on the Back-side in its proper Form, with similar Distances in the Hour Lines ; but then the Manner of numbering the Hours must be varied, in as much as the East Dial begins to shew the Hour at Sun rise and ends a little before Noon, and the West Dial does not begin till a little after 12 and continues till Sun-set. See Figure 8, which shews at one View how the Hours are numbered, much readier than Words can express.

Now to delineate the Lines by Rule and Compass, observe that as the West is the Reverse of the East, draw a Line to represent the Horizon as before, viz. HG, and towards the Contrary End of that Line, from what appears in the East Dial, pitch upon a convenient Point as G, and draw GD, making the Angle DGH equal to the Complement of Latitude, that GD may represent the Elevation of the Equinoctial ; having marked the Point D in a convenient Part of the Line, draw the Perpendicular DEC, and set the Extent *a* as before from D to E, and draw the obscure Circle to form the Quadrants, which being divided as before, and Lines drawn from the Center E to the Contingents, we get the Hour Lines as in Fig. 7 aforesaid ; the Stile in both the East and West Dial is fixed parallel to the six o'Clock Line, pointing to the Pole, distant from the
Face

Face of the Dial the Length of the Line $a\alpha$ taken from the Fundamental.

Example XI.

To delineate the Horizontal Dial alone, and leave sufficient Space for the Stile, without cutting the Paper into two Parts to make Room for it; and as it is the most useful and perfect of any of the common Sorts of Dials, shewing all the Hours of the Artificial Day at all Times of the Year, if no Impediment lies in the Way, it therefore deserves more Notice than any of the Rest; for which Reason we shall shew how to delineate the same without having Recourse to others.

Suppose then it be required to delineate a Horizontal Dial for Latitude $53^{\circ} 30'$ North, and leave Space for the Stile.

First prepare a Fundamental Diagram to the Size most proportionable for the design (or intended Draught,) in the same Manner that the Diagram was formed before in Fig. 1. (See Page 173.)

Take a smooth Plane, Plate of Metal, or Piece of Paper, and having chosen a convenient Place for the Six o'Clock Line as at E (Fig. 9.) draw through it the Line CD to represent East and West; and through the same Spot E, at right Angles to CD, draw the Meridian or Twelve o'Clock Line AB. Then have recourse to the Diagram (as Fig. 1.) from which take the Extent or Distance ac , and set it from E to e on the Line AB, and then from the said Diagram take the Distance $a\alpha$ and set it from e to $\odot$ on the same Line, and through the two Points e and $\odot$ draw two obscure Lines parallel to the Line CD, as cd and rs . Next, with one Foot of your Dividers in $\odot$, and the said Extent $a\alpha$, draw the obscure Quadrant of a Circle en , which

which mark into Six equal Divisions, and through each Mark draw a Line from the Center $\odot$ till it intersects the Line cd , as at 1, 2, 3, 4, 5, &c. Then from the Center E above, draw Lines to each of said Marks of Intersection, and they will be the Hour Lines for that Quarter of our Horizontal Dial, or the East Side, viz. I. II. III. IV. V. and then VI. which are the Afternoon Hours. In the next Place, leave a Space on the Right Side of the Line AE , eB equal to the intended Thickness of the Stile, and draw the Line be , &c. Then from the new Point e on the Line ed , set off Marks of Division for the Morning Hours, viz. 11, 10, 9, 8, 7, in the same Manner, and with the same Extent, the Marks were set off for the Afternoon Hours on the other Side of the Stile from e on the Line ee , then through these new Marks draw Lines from the Right Hand Centre of the Stile at E , for the Hour Lines of the Western Quarter, which are to be marked XI. X. IX. VIII. VII. to VI. except those before Six in the Morning, and after Six in the Evening, which are commonly found by extending their opposite Hour Lines to the contrary Side, and marking those on the West Side for Morning IV. V. and those on the East Side VII. VIII. for Evening, &c. And as for Quarters of Hours or smaller Divisions, they may be managed on the Quadrant en after the same Manner that we seek the Divisions for the Hour Lines. Lastly with Respect to the Stile, we have already shewn that it must form an Angle at the Centre E , viz. $\angle E B$, equal to the Latitude of the Place or Elevation of the Pole, and be placed upon the Meridian, or 12 o'Clock Line pointing towards the North, which must lie with the whole Plane of the Dial as Horizontal as possible when fixt for Service. And if such a Dial be made broad or very Large, with the North Point of the Stile standing Perpendicular over any East and West Line drawn on the Plate in it's Horizontal Position, it will be very easy from thence to shew how a Direct South Dial or

even

even any upright Decliner may be drawn or formed from it, by holding a Plane or Plate of Metal in a Perpendicular Position at the North End of the Stile; and by extending or contracting the Length of the Stile, we might be able to fix and draw the Hour Lines of Dials upon either reclining or inclining Planes in the same Manner, (see Fig. 11. 12.)

I shall only add one Note more, and that is, If a Horizontal Dial be drawn for any particular Latitude, as suppose $53^{\circ} 20'$ North, it would serve for a South Dial in any other Place whose Latitude is equal to the Complement of the same; many Places might be found in *Persia*, *China*, *Japan* and *Carolina*, that have their Latitude equal to the Complement of ours.

Example XII. The direct South Dial is projected the same Way as we did the foregoing Horizontal, with this Difference.

Instead of Setting off the Extent ac (taken from the Fundamental Diagram) from E to e ; we must for the South Dial set off the Distance ad instead of it, taken from the same Diagram; but the Extent EB is the same in both, and in all other Respects we proceed as in the Horizontal; (Fig. 9.) However remember the Stile is to be equal to the Complement of Latitude; and a South Dial at the most serves only from 6 Morn. till 6 at Night. The remaining Hours must be transferred as it were to the contrary Side from the upper Part of the South Dial; and the Numbers of the Hours inverted to make a North Dial (see Fig. 13 and 10.) In short the drawing of a direct South Dial for one Place, is no more than the drawing a Horizontal Dial in the Complement of its Latitude; or if a Plane were erected to stand Perpendicular over the Line rs , in the Horizontal Dial (Fig. 9.); the Point of its Stile erected, would determine the Point in the applied Plane from whence the

Hour

Hour Lines are to be drawn to meet the Intersections on the Line *r s*.

Example XIII. To delineate an erect South Dial, or an upright Dial to face the South, on Paper or a Plane, from an Horizontal Dial.

1. From a prepared Diagram (as Fig. 11.) draw a Horizontal Dial, as suppose *E W*, *R L*, (in Fig. 10.) Let the Line *E W* be drawn and extended parallel to the Six o'Clock Line, or *R L*, so as to cross the Meridian or Twelve o'Clock Line on it's very Extremity, at Right Angles, and call the Line *E W* the Line of Contingence; then extend the several Hour Lines from the Centre $\odot$ till they intersect the Line of Contingence *E W*; next from the Centre $\odot$ extend the 12 o'Clock Line, or Perpendicular, towards the Point *A*; having done this take from the same Diagram (Fig. 11.) the Extent *ad* and set it from the Extremity of the 12 o'Clock Line to *E*, and then *E* will be the Centre of our South Dial; from which Centre if we draw Lines to the several Intersections on the Line of Contingence we obtain all the Hour Lines of our South Dial from 6 in the Morning till 6 in the Evening: And we have already shewn the Height of the Stile: You may inclose your Hour Lines, or inscribe the Hours in a Square, a Circle, Polygon, or any other Figure; see Middle Part of Figure 10.

Example XIV. Now to form or delineate a North erect, or an upright Dial to face the North.

Consider how long the Sun can shine, in the Latitude given, before 6 in the Morning, and after 6 in the Evening; and extend the opposite Hour Lines upwards through the Centre *E* to the opposite Side of the Dial Plate

Plate in a South Dial (Fig. 10.) Then if you cut off the upper Part of this Dial Plate above the Line CD (or the Six o'Clock Line) you have in Effect the Hour Lines of the North erect Dial ; but when it is set up for Use it must be turned so as to face the North.

Altho' some Writers on Dialling seem not to notice it, the lower Part of the North Dial should be continued below the 6 o'Clock Line, to near 8 on one Side for the Morning Hours, and to near 4 on the other Side for the Evening, because the Sun will shine on the North Plane, on the longest Days 'till past 7 in the Morning, and will pass the West, and shine on it again, before 5 in the Evening. See Fig. 13. A North erect, direct Dial.

Example XV.

Now from an Horizontal Dial to delineate an erect Decliner ; suppose on a Plane declining from the South towards the West 15 Degrees.

Take the Fundamental Lines of a Horizontal Dial, as contained between the Lines CD and the 6 o'Clock Line that runs through F, in Fig. 12. (being of the same Dimensions of that in Figure 10, taken from the Diagram Fig. 11.) and mark upon the Line of Contingence or CD where the several Hour Lines intersect it. Then erect the Perpendicular Line F 12 E, and make the Extent 12 E equal to the Extent *ad* taken from the said Fundamental (Fig. 11.) Now 'tis plain that E would be the Point or Center of an erect South Dial to be drawn from hence, but we want a proper Centre for a Plane declining to the West 15 Degrees ; therefore draw the Line NO through the Point of Intersection for 12 o'Clock, making the Angle 12 OD equal to 15 Degrees ; next upon the Line NO erect a Perpendicular from the Point of Intersection at 12, and set off the Extent *ad*, as before, from 12 to M, equal to 12 E, which Point M will be the Centre of our new declining Dial : Then in the next Place continue the Hour Lines

of

of the Horizontal Dial from the Point F till they intersect the Line N O, (that is to say on the Western Side towards N, but on the East Side towards O the Lines are contracted), which being done draw the Hour Lines for the Decliner, from the Centre M to each of the Intersections, and number the Hours as in Fig. 12. between the Arches.

Now to make out the Stile; draw a Perpendicular from the Point F to Line N O, as F, G: And then, from the Point of Intersection G, draw a Line to the Point M, and make the Lines M G and G F the two Legs of a Right Angled Triangle, which Triangle will be the true Form of the Stile, the Side M G standing partly upright when the Decliner is fixt for use: See the Triangle *g m f*.

Now if I wanted an Erect Dial declining as many Degrees from the South Eastward, *viz.* 15° . If my Paper be tolerably thin it will appear on the Backside of this (Fig. 12.) Or otherwise if we turn this Draught over, with its Face downwards, as it were, upon the Axis Z L upon a Piece of clean Paper, and mark the drawings with the Point of a Needle, we shall have it; and as for the Hours, observe as this Dial is to stand with its Face Southwards, and the Observer with his Face Northward, the Morning Hours must be marked on his Left Hand, or the West Side of the Dial, and the Evening Hours on the Right or Eastside:

And again, having drawn these two Decliners, we may obtain two more, *viz.* a North West, and a North East Decliner, by looking at the Back of these, or otherwise by turning them upside down, as it were, upon the Axis R L, and marking them off; but Care must be taken how the Hours are to be numbred, *viz.* the Morning Hours to be on the West Side of the Observer's View, and the Evening Hours on the East Side: And the Stile in Planes facing the North must always point to that Pole.

Recliners or Inclining Dials, of Course would follow
next,

next, but as they would take up Room, and this Introduction being already spun out to a greater Length than we intended, we shall conclude with an Invitation to some more skilful Hand, and more at Leisure, to proceed through the whole System of Horography, in all its Varieties : Which we hear is already begun by *James Parr*, a very eminent Mathematician ; and perhaps the Learner will be induced, from this familiar Introduction, to pursue his Plan through all the Methods of Trigonometrical Calculation, as well as the Geometrical Construction of all the several Figures and Forms that a Dial can possibly be represented in.

A ready Method of drawing a Meridian-Line in order to place Dials.

The easiest and most expeditious way of drawing a Meridian Line is this : Make four or five concentric Circles, about a quarter of an Inch from one another, on a flat Board about a Foot in Breadth ; and let the outmost Circle be but little less than the Board will contain. Fix a Pin perpendicularly in the Center, and of such a Length that it's whole Shadow may fall within the innermost Circle for at least four Hours in the Middle of the Day. The Pin ought to be an eighth Part of an Inch thick, and to have a round blunt Point. The Board being set exactly level in a Place where the Sun shines, suppose from eight in the Morning till four in the Afternoon, about which Hours the End of the Shadow should fall without all the Circles ; watch the Times in the Forenoon, when the Extremity of the shortening Shadow just touches the several Circles, and *there* make Marks. Then, in the Afternoon of the same Day, watch the lengthening Shadow, and where it's End touches the several Circles in going over them, make Marks also. Lastly, with a Pair of Compasses, find

find exactly the Middle Point between the two Marks on any Circle, and draw a streight Line from the Center to that Point; which Line will be covered at Noon by the Shadow of a small upright Wire, which should be put in the Place of the Pin. The Reason for drawing several Circles is, that in Case one Part of the Day should prove clear, and the other Part somewhat cloudy, if you miss the Time when the Point of the Shadow should touch one Circle, you may perhaps catch it in touching another. The best Time for drawing a Meridian Line in this Manner is about the Summer Solstice; because the Sun changes his Declination slowest and his Altitude quickest in the longest Days.

If the Casement of a Window on which the Sun shines at Noon be quite upright, you may draw a Line along the Edge of it's Shadow on the Floor, when the Shadow of the Pin is exactly on the Meridian Line of the Board: And as the Motion of the Shadow of the Casement will be much more sensible on the Floor, than that of the Shadow of the Pin on the Board, you may know to a few Seconds when it touches the Meridian Line on the Floor; and so regulate your Clock for the Day of Observation by that Line and the Equation of Time for that Day.

If the foregoing Method could be done at all Times as exactly as about the Time of the Solstices, (about which Times only it is exact, but most erroneous at the Equinoxes) it would be preferable to all others; but there is another Method of finding a Meridian-Line by the Help of the Polar Star in the Night, when 'tis known to be on the Meridian; for which Purpose some convenient Plane should be chosen whereon to erect two Perpendicular Poles so that one shall be directly interposed between the Pole-star and the other, which is to be proved by different Trials, and is by many esteemed to be the best Method: However for setting up any small Dial, a large double Equinoctial Ring-Dial may answer the
End

End, and so may a well-regulated Watch or Clock, the Equation of Time for that Day being applied.

The foregoing Instructions, as an Introduction to Dialling, well understood, may be sufficient, with close Application, to lead a tolerable Genius into a perfect System of the whole Art; which if this small Treatise meet with Encouragement, we propose to publish in due Time at a reasonable Price; and to treat in our Course not only of Decliners, Incliners and Recliners, but also of Reflecting Dials in general, whether they are to be constructed mechanically alone, or by Trigonometry and Arithmetic.

And also to shew a short and easy Method of discovering the Declination of any Wall, and the Inclination or Reclination of any Plane, by a new contrived Instrument, and universal Dial constructed for that Purpose, and all the Uses of the Declinatory.

How to tell the Hour of the Night by the Shadow of the Moon on a Sun-dial.

First seek the Time of the Moon's Southing, either by the common Method as shewn in Page 159, which is not sufficiently exact for this Purpose; or else in a true Table of the Southing for every Day (such as we usually have in *Smith's Ephemeris*); then if the Shadow fall among the Morning Hours upon a Sun-Dial, whatever the Shadow wants of 12 o'Clock by the Dial, subtract from the Time of the Moon's Southing: But if the Shadow fall among the Afternoon Hours, so much as it is past 12 by the Dial add to the Moon's Southing Time; the Difference in the first Case, and the Sum in the second, is the Hour and Minute of the Night nearly, but needs a further Correction to make it exact, which may be done thus,

For every Hour the Shadow wants of 12 subtract 2 Minutes, and for every Hour past 12, add 2 Minutes, which gives the Hour of the Night, corrected.

Example

Example I.

February 8, 1770, the true Time of the Moon's Southing was at 48 Minutes past 10 at Night, and I observing the Shadow to fall upon the 8 o'Clock Hour-Line, then what was the Hour of the Night?

	H.	M.
True Time of Moon's Southing	10	48
Shadow short of 12 subtract	4	0
Remains the Hour of the Night, nearly	6	48
Correction for 4 Hours subtract		8
Remains the Hour of the Night	6	40

Example II.

March 10, 1770, the Moon Souths at 19 Minutes past 11 at Night, and observing the Shadow upon the Dial to fall on the Hour 1. 30', I desire to know the true Hour of the Night?

	H.	M.
True Time of Moon's Southing	11	19
Shadow past 12 add	1	30
Sum, is the Hour of the Night	12	49
Correction add		3

Hour of the Night, corrected 12 52, from which subtract 12 Hours remains 52 Minutes after Midnight, or in the Morning of the following Day.

This Method will give the Time the more exact, the nearer the Moon is to the Meridian.

F I N I S.

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